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(54) ZOOM LENS

(57)Abstract:

PURPOSE: To decrease the fluctuations in various aberrations by consisting a first lens group of a stationary front group which has negative and positive lenses and a moving rear group which has a negative lens and two positive lenses and specifying the focal length of the rear group and the Abbe numbers of the material of the negative and positive lenses so as to satisfy a prescribed conditions.

CONSTITUTION: The first lens group F consists of the stationary front group 11 and the rear group F12 of positive refracting power for focusing. The rear group 12 has the one negative lens and the two positive lenses and the focusing is executed by moving the rear group F12 to the object side. A compensator C is moved to correct the fluctuation in the image plane associated with the variable power. The zoom lens has a relay group R of positive refracting power as a fourth group. The zoom lens satisfies the conditions $\nu 11N-\nu 12P<-55$, $\nu 11N-\nu 21N<-10$, $-0.65<f21/FC12<-3.5$ when the focal length of the rear group is defined as FC12 and the Abbe numbers of the materials of the negative lens and the positive lens are defined as $\nu 11N$, $\nu 12P$, the

focal length of negative lens and the Abbe numbers of the material are respectively defined as f21, ν 21N.

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CLAIMS

[Claim(s)]
[Claim 1] In a zoom lens with the 4th RENSU group which has in order the 1st lens group of forward refractive power, the 2nd lens group of the negative refractive power for variable power, the 3rd lens group that amends the image surface fluctuation accompanying variable power, and an image formation operation from a body side This 1st lens group consists of the rear group which has the pre-group of immobilization, and forward refractive power at the time of a focus, and moves to a body side at the time of the focus to a near body from an infinite distance body. Said pre-group has two lenses with which at least one negative lens LN11 and at least one positive lens LP12 became independent. Said rear group It has at least one negative lens LN21 and

at least two positive lenses which are arranged from a body side the 1st or the 2nd. Respectively the Abbe number of the quality of the material of Fc12, and said negative lens LN11 and positive lens LP12 for the focal distance of said rear group nu11N and nu12P, the time of setting the focal distance of said negative lens LN21, and the Abbe number of the quality of the material to each f21 and nu21N -- nu11N-nu12P <-55nu11N-nu21N -- < -10-6.5<f21/Fc12 -- < -3.5 -- the zoom lens characterized by satisfying conditions.

[Claim 2] The zoom lens of claim 1 characterized by satisfying the conditions which become Pgd=(ng-nd)/(nF-nc)<1.36-0.00208xnu21 when the thing of d line (wavelength of 587.56nm), g line (wavelength of 435.83nm), an F line (wavelength of 486.13nm), and C line (wavelength of 656.27nm) is respectively set to nd, ng, nF, and nc among the refractive indexes of the quality of the material of this negative lens LN21.

[Claim 3] When the radius of curvature of the lens side by the side of the body of this negative lens LN21 and the image surface is respectively set to ra and rb, it is [External Character 1].

$$1.1 < \left|\frac{r_b+r_a}{r_b-r_a}\right| < 5.6$$

The zoom lens of claim 1 characterized by satisfying the becoming conditions.

[Claim 4] When the focal distance of FT, FNT, and this 1st lens group is respectively set to F1 for the focal distance and the f number of the whole system in a tele edge, they are 1.0<FN 1< 1.7, however FN1=F1/(FT/FNT).

The zoom lens of claim 1 characterized by satisfying the conditions which become 0.9<FC12 / F1<1.1.

[Claim 5] It is [outside 2] when the focal distance of the i-th lens of f11i, nu11i, and said 12th group and the Abbe number of the quality of the material are respectively set to f12i and nu12i for the focal distance of the i-th lens of said 11th group, and the Abbe number of the quality of the material.

$$-2.5\times10^{-4} < EF \leqq 0 \qquad \text{但し}\ EF=\Sigma\frac{1}{f11i\times\nu11i}$$

$$0 \leqq EM < 2.4\times10^{-4} \qquad \text{但し}\ EM=\Sigma\frac{1}{f12i\times\nu12i}$$

$$-1.28 < EF/EM < -0.75$$

The zoom lens of claim 1 characterized by satisfying the becoming conditions.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the zoom lens of the f number 1.7 of the short wide angle edge of the near object distance using the so-called inner focus type which performs a focus by some lens groups in the 1st group especially, the about 13-to-44-zoom ratio diameter of macrostomia, and a high variable power ratio about the suitable zoom lens for a television camera, a video camera, a photographic camera, etc.
[0002]
[Description of the Prior Art] From before, with the miniaturization of a television camera in zoom lenses, such as a television camera, the whole lens system is small and, moreover, the thing of the diameter ratio of macrostomia and a high variable power ratio is demanded.
[0003] By the method which performs focusing (focus) by the lens group located in a body side from a variable power lens group as a zoom lens, since zooming (variable power) and focusing can be performed independently, the device for migration can be simplified and the focus migration by zooming does not arise, but to the fixed object distance, it does not depend on a zoom location, but has the features that focusing can be performed in the fixed amount of deliveries.
[0004] Among such zoom lenses, sequentially from a body side The 1st group of the forward refractive power for a focus (focussing-lens group), The 3rd group of refractive power forward [for amending the image surface changed in connection with the 2nd group (variable power lens group) of the negative refractive power for variable power, and variable power], or negative (correcting lens group), In the so-called 4 group zoom lens which consists of an aperture diaphragm and four lens groups of the 4th group (relay lens group) of the forward refractive power for image formation What adopted the so-called inner focus type which is made to move some lens groups in the 1st group, and performs a focus is proposed by JP,59-4686,B.
[0005] In this official report, the 1st group is constituted from three lens groups, the 11th group of negative refractive power, the 12th group of forward refractive power, and the 13th group of forward refractive power, the 12th group is moved to an image surface side, and the focus applied to a point-blank range body from an infinite distance body is performed.
[0006] Moreover, in JP,52-109952,A, JP,55-57815,A, JP,55-117119,A, JP,61-53696,B, and JP,52-41068,B, the 1st group is divided into two or more lens groups in 4 group zoom lens, among those the lens group by the side of a body is most considered as immobilization at the time of focusing, and it is considering as inner focusing which moves a part of lens group by the side of the back image surface from it at the time of focusing.
[0007] Moreover, in JP,52-128153,A, the 1st group is divided into two lens groups, on

the occasion of focusing from an infinite distance body to a finite distance body, spacing of the two lens groups is moved so that it may become large, and focusing is performed.

[0008] Since contiguity photography, especially pole contiguity photography become easy and it is generally carrying out by the effective diameter of the 1st group becoming small compared with the zoom lens which is made to move the 1st whole group and performs a focus, and it becoming easy to miniaturize [of the whole lens system] the zoom lens of an inner focus type, and moving the lens group of small measuring further comparatively, the driving force of a lens group is small and ends, and it has the features, like quick focusing is made.

[0009]

[Problem(s) to be Solved by the Invention] In a zoom lens, it is a diameter ratio of macrostomia (for example, f numbers 1.7-3.3), and a high variable power ratio (13 to about [For example, a variable power ratio] 44), and it is necessary to set up appropriately refractive power (power), a lens configuration, an achromatism assignment of each lens group, etc. for moreover obtaining high optical-character ability over all variable power range and all focal range.

[0010] In order for aberration fluctuation to obtain little high optical-character ability over all variable power range and all focal range generally, it is necessary to make small the amount of aberration which makes power of each lens group small and is generated by each lens group, or to make the lens number of sheets of each lens group increase, and to increase the degree of freedom on aberration amendment. For this reason, if it is going to attain the zoom lens of a high variable power ratio by the diameter ratio of macrostomia, air spacing each lens between groups will surely become large, or lens number of sheets will increase, and the trouble that the whole lens system turns profound length size will arise.

[0011] moreover, the latest zoom lens for broadcast -- setting -- more -- wide-angle-izing -- more -- high variable power -- a ratio ---izing is desired and improvement in the short-distance engine performance and compaction of M.O.D (the shortest photography distance) are being further set to one of the important elements on a specification and the image effectiveness.

[0012] However, fluctuation of fluctuation of many aberration by focusing especially spherical aberration, axial overtone aberration, astigmatism, etc. was remarkable in the zoom lens for broadcast, and it was very difficult to maintain optical-character ability good. so that the aberration fluctuation at this time generally has a large focal distance -- the f number -- small -- a large -- there was an inclination which becomes large, so that M.O.D was so short that an aperture ratio.

[0013] Speaking of the above-mentioned focusing method, with the zoom lens of JP,52-109952,A, JP,55-57815,A, and JP,55-117119,A, on aberration amendment, since there is much configuration lens number of sheets of the 1st group, the lens

whole system will be enlarged and complicated and weight will also become heavy.

[0014] Although the 1st group has comparatively simple composition with the zoom lens of JP,61-53696,B, since air spacing of the 1st group at the time of an infinite distance focus and a variable power lens group is greatly open and the focal group of negative refractive power moves to an image surface side further at the time of a short-distance focus, the height of the axial outdoor daylight line by the side of a wide angle will become high by the 1st group, and a lens system will be enlarged.

[0015] Although the 1st group is made to a comparatively simple configuration and it is suitable for a miniaturization with the zoom lens of the delivery method of the 1st group, fluctuation of the spherical aberration especially by focusing and axial overtone aberration becomes large. For example, spherical aberration falls on an undershirt and axial overtone aberration also serves as an undershirt as it becomes a short-distance focus.

[0016] The mechanism of the aberration fluctuation at this time is explained below.

[0017] Drawing 33 is the explanatory view of the light-gage paraxial system when constituting the 1st group from the 11th group L11 of negative refractive power, and the 12th group L12 of forward refractive power. Drawing 34 is the lens sectional view of the 1st typical group L1 in 4 group zoom lens.

[0018] In drawing 33 , practice is a location at the time of an infinite distance body focus, and a dotted line is a location at the time of M.O.D. Since it is a'<a when ha', hb', the 11th group, and an inclination 12th between groups are respectively made into a' for the incidence quantity to the 1st group and the 2nd group of a paraxial ray at the time of M.O.D which shows ha, hb, the 11th group, and an inclination 12th between groups for the incidence quantity to the 11th group and the 12th group of a paraxial ray at the time of the infinite distance focus shown by practice by a and the dotted line respectively, it is hb-ha<hb'-ha'.

[0019] In the 3rd aberration theory, the 3rd aberration coefficient L of axial overtone aberration is proportional to the square of the paraxial-ray quantity h, and the 3rd aberration coefficient I of spherical aberration is proportional to the 4th power of the paraxial-ray quantity h here. By this focal method, from the time of an infinite distance body, since the direction at the time of M.O.D becomes large to a plus direction and, as for axial overtone aberration, a multiplier I becomes [a multiplier L] large to a plus direction similarly to an undershirt, spherical aberration is also changed to an undershirt.

[0020] With the zoom lens of JP,52-41068,B, as shown in drawing 36 , the 1st group is divided into two lens groups, among those negative refractive power with weak abbreviation no power is given to the 11th group L11 by the side of a body, it considers as immobilization on the occasion of focusing, and FOSHINGU is performed by moving the 12th group L12 of the forward refractive power by the side of the image surface.

[0021] This is made into the light-gage paraxial system of the 11th group and the 12th group, and it is shown in drawing 35 . As shown in drawing 35 , the 12th group is shown as migration of the principal point.

[0022] A continuous line is a paraxial ray at the time of the focus of an infinite distance body, and it is hb−ha<hm−hfhb'−ha'**hm'−hf' respectively as compared with hf', hm', then drawing 33 (the 1st group delivery method) about the incidence quantity to the 11th group and the 12th group of a metal beam of light at the time of M.O.D which shows respectively the incidence quantity to the 11th group at this time, and the 12th group by hf, hm, and the dotted line.

[0023] Therefore, according to the zoom lens of this official report, compared with the delivery method of the 1st group, it becomes possible to make small variation of the 3rd spherical-aberration multiplier I of the time of infinite distance to the time of M.O.D, and the axial overtone aberration coefficient L. Therefore, rather than the delivery method of the 1st group, fluctuation of the spherical aberration by focusing and axial overtone aberration can be decreased. However, the amount of fluctuation cannot be satisfied and the further improvement is still desired.

[0024] With the zoom lens of JP,52-128153,A, the 1st group was divided into two lens groups, the both sides were moved at the time of focusing, and the circumference engine performance is mainly improved by enlarging spacing of the two lens groups as it becomes a short-distance focus. However, according to the example, spherical aberration has also fallen on the undershirt at the time of a short-distance focus, and the main engine performance is getting worse conversely.

[0025] It is necessary to set up appropriately the refractive power and the lens configuration of each lens group for attaining high specification-ization, attaining small lightweight-ization of the whole zoom lens which is generally a request of the latest user in addition to this. Especially in 4 group zoom lens, the brightness of the refractive power which the 1st group (front ball group) which influences the magnitude and weight of the lens whole system most shares, and a lens group is an important element.

[0026] Furthermore, in a high definition broadcasting format like Hi-Vision, especially in order to obtain a zoom and optical-character ability high throughout a focus, the aberration fluctuation by the looking-far side of a zoom or the focus must be controlled. If the absolute value of fluctuation of axial overtone aberration or the chromatic aberration of magnification or the amount of aberration itself is not controlled especially as much as possible, it is becoming impossible among these, to acquire high resolution. For this reason, it is becoming an important element how the 1st group (front ball group) which participates in the aberration by the side of a tele edge or the aberration by the focus greatly is made to constitute.

[0027] And, this invention adopting the inner focus method which is made to move some lens groups of the 1st group for focuses which constitutes 4 group zoom lens on

an optical axis, and performs a focus In case diameter[of macrostomia]-izing and high variable power-ization are attained, by setting up the lens configuration of each lens group appropriately the about 1.7 f number of a wide angle edge with [decrease fluctuation of many aberration, such as variable power and spherical aberration accompanying focusing, and chromatic aberration, and] high optical-character ability over all variable power range and all focal range, and a variable power ratio -- it aims at offer of the zoom lens of about 13 to 44 diameter ratio of macrostomia, and a high variable power ratio.

[0028]

[Means for Solving the Problem and its Function] The 1st lens group of refractive power more nearly forward than a body side to order in the zoom lens of this invention, In a zoom lens with the 2nd lens group of the negative refractive power for variable power, the 3rd lens group of the forward or negative refractive power which amends the image surface fluctuation accompanying variable power, and the 4th lens group that has an image formation operation This 1st lens group consists of the pre-group of immobilization, and the rear group which moves to a body side at the time of the focus to a near body from an infinite distance body at the time of a focus. Said pre-group has two lenses with which at least one negative lens LN11 and at least one positive lens LP12 became independent. Said rear group It has at least one negative lens LN21 and at least two positive lenses which are arranged from a body side the 1st or the 2nd. the focal distance of said rear group -- the Abbe number of the quality of the material of Fc12, and said negative lens LN11 and positive lens LP12 -- the focal distance of each nu11N, nu12P, and said negative lens LN21, and the Abbe number of the quality of the material -- each f21 and nu21N ** -- the time of carrying out -- nu11N -nu12P <-55 -- (1)

nu11N-nu21N <-10 -- (2)

- 6.5<f21/Fc12<-3.5 -- (3)

It is characterized by satisfying the becoming conditions.

[0029] In addition, when the thing of d line (wavelength of 587.56nm), g line (wavelength of 435.83nm), an F line (wavelength of 486.13nm), and C line (wavelength of 656.27nm) is respectively set to nd, ng, nF, and nc among the quality of the materials of said negative lens LN21 in claim 2 of this invention, it is Pgd=(ng-nd)/(nF-nc)<1.36-0.00208xnu21. -- (4)

It is [0030] when the radius of curvature of the lens side by the side of satisfying the becoming conditions, the body of said negative lens LN21, and the image surface is respectively set to ra and rb.

[External Character 3]

$$1.1 < \left|\frac{r_b+r_a}{r_b-r_a}\right| < 5.6 \qquad \cdots (5)$$

When the focal distance of FT, FNT, and this 1st lens group is respectively set to F1 for the focal distance and the f number of the whole system in satisfying the becoming conditions and a tele edge, it is 1.0<FN 1< 1.7. -- (6)
However, FN1=F1/(FT/FNT)
0.9<FC12/F1<1.1 -- (7)
It is [0031] when the focal distance of the i-th lens of f11i, nu11i, and said 12th group and the Abbe number of the quality of the material are respectively set to f12i and nu12i for the focal distance of the i-th lens of satisfying the becoming conditions and said 11th group, and the Abbe number of the quality of the material.
[External Character 4]

$$-2.5\times10^{-4}<EF\leq0 \quad 但し\ EF=\Sigma\frac{1}{f11i\times\nu11i} \quad \cdots(8)$$

$$0\leq EM<2.4\times10^{-4} \quad 但し\ EM=\Sigma\frac{1}{f12i\times\nu12i} \quad \cdots(9)$$

$$-1.28<EF/EM<-0.75 \quad \cdots(10)$$

It is characterized by satisfying the becoming conditions.
[0032]
[Example] Drawing 1 , drawing 2 , drawing 3 , and drawing 4 are the lens sectional views in the wide angle edge of the numerical examples 1, 2, 3, and 4 of this invention respectively. For drawing 5 - drawing 11 , the aberration Fig. of the numerical example 1 of this invention, drawing 12 - drawing 18 are [the aberration Fig. of the numerical example 3 of this invention, drawing 26 - drawing 32 of the aberration Fig. of the numerical example 2 of this invention, drawing 19 - drawing 25] the aberration Figs. of the numerical example 4 of this invention.
[0033] In drawing 1 - drawing 4 , F is the 1st lens group (front ball lens group) of forward refractive power, and consists of two lens groups, the pre-group F11 of immobilization, and the rear group F12 of the forward refractive power for focuses. The pre-group F11 has at least one negative lens LN11 and two lenses with which at least one positive lens LP12 became independent. The rear group F12 has at least one negative lens LN21 arranged from a body side the 1st or the 2nd, and at least two positive lenses. The focus from an infinite distance body to a point-blank range body is moved to a body side, and is performing the rear group F12.
[0034] V is BARIETA of the negative refractive power for the variable power as the 2nd group, and is performing variable power from a wide angle edge (wide) to a tele edge (call) by making it move to an optical-axis top image surface side in monotone. The 2nd group V is changed in the field where an image formation scale factor includes actual size (-1 time) in the case of variable power.
[0035] C is the compensator of refractive power forward [as the 3rd group], or negative, and it is moving in order to amend the image surface fluctuation accompanying variable power. SP extracts and R is the relay group of the forward

refractive power as the 4th group. G is color-separation prism, a light filter, etc., and this drawing shows it as a glass block.

[0036] Since the amount of deliveries of the 1st group becomes fixed to the same object distance in each focal distance, the so-called front ball focus method which generally performs focusing by the 1st whole group by the side of a body most in 4 group zoom lens has the features that lens barrel structure becomes easy.

[0037] However, in order for the 1st group to have forward refractive power, for the effective diameter of the 1st group to increase in order to secure an axial outdoor daylight bundle in order that the 1st group may move to a body side in case focusing is made a point-blank range body in a wide angle edge in the zoom lens containing an extensive field angle, and to move the 1st group with comparatively heavy weight, driving torque increases, and a quick focus becomes difficult.

[0038] Then, in the zoom lens with which it has the above-mentioned configuration in this invention, and is satisfied of conditional expression, by adopting the inner focus method which considers a pre-group F11 for focusing from an infinite distance body to a point-blank range body as immobilization, and is held by moving a rear group F12 to a body side, increase of the lens effective diameter of the 1st group F is prevented, the miniaturization of the whole lens system is attained, and shortening of point-blank range is attained further.

[0039] Furthermore, the pre-group F11 of this immobilization separates at least one negative lens LN11 and comparatively small space spacing in order, and constitutes them from a body side by at least one positive lens LP12.

[0040] In the pre-group F11 of this immobilization, it is [difference / of the Abbe number of the quality of the material of a negative lens LN11 and positive lens LP12] large in that difference like conditional expression (1), and the Abbe number of a negative lens L21 is greatly set up for the difference of the Abbe number of the negative lens LN11 of a pre-group, and the negative lens L21 of a rear group like conditional expression (2). This has amended fluctuation of the chromatic aberration by zooming or focusing good.

[0041] In addition, it did not carry out using a negative lens LN11 and positive lens LP12 as a cemented lens, but comparatively small air spacing is separated and arranged. The space which changes with the radius of curvature of the lens side by the side of the image surface of the negative lens LN11 which sandwiched this air spacing, and the radius of curvature of the lens side by the side of the body of positive lens LP12, and the so-called air lens are in abbreviation etc. by carrying out, and radius of curvature constitutes them in the convex positive meniscus lens configuration at the body side.

[0042] By constituting this air lens, when the degree of freedom of the (a) design increases, an assignment of aberration amendment is mitigated.

(b) Since the rapid degree of each aberration can be performed, especially control of

high order aberration becomes simple.
(c) In order that a negative lens LN11 may separate, in order to extrude the principal point of a front ball lens group, contribute to a miniaturization.
The effectiveness of ** is pulled out.
[0043] Furthermore, the rear group F12 which is a focal migration group has at least one negative-lens-and-at-least-two positive lenses which are arranged the 1st or the 2nd from the body side, and in order to obtain high optical-character ability corresponding to high variable power and short MOD, it constitutes them with the necessary minimum design degree of freedom which amends fluctuation of spherical aberration, astigmatism, distortion aberration, chromatic aberration, etc.
[0044] Moreover, he defines the focal distance of the negative lens LN21 of a rear group, and is trying to control the aberration fluctuation at the time of focusing like conditional expression (3).
[0045] If the upper limit of conditional expression (3) is exceeded and the focal distance Fc 12 of the rear group which is a focal migration group becomes large, the amount of delivery by focus operation will increase. For this reason, the dead space in the front ball lens group F will increase, and the whole front ball lens group which influences the magnitude and weight of a zoom lens will be enlarged. On the contrary, if a minimum is exceeded and the focal distance Fc 12 of a rear group becomes small, although the whole front ball lens group can attain a miniaturization, since the radius of curvature of each lens element which constitutes a rear group F12 becomes small rapidly, it will become difficult to amend the aberration fluctuation by zooming or focusing.
[0046] Although the purpose of the invention in this application is attained under the above configuration, he is trying to obtain very high optical-character ability also with careful attention to the quality of the material used for each lens element in addition to this. For example, when the primary achromatism is carried out about two wavelength like C line and an F line, a secondary spectrum remains. Although the lens by which color correction was carried out about three wavelength included to g line as opposed to this primary achromatism is called apochromat, in order to attain this apochromat, it constitutes from a positive lens and a negative lens, and it is necessary to use the quality of the material to which the value of partial dispersion is equal in addition to the primary achromatism of the chromatic-aberration amendment by having detached those Abbe numbers greatly.
[0047] A partial dispersion ratio is primary dispersion nF-nc here. Two wavelength lambda 1 of the receiving arbitration, and partial dispersion of lambda 2 [0048]
[External Character 5]
$n_{\lambda_1} - n_{\lambda_1}$

It is the thing of a ** ratio.

[0049] If achromatism is made about three points, C line, an F line, and g line, since a chromatic-aberration curve is continuation, a secondary spectrum will become very small to a visible region at large [400nm - 700nm].

[0050] Then, about the quality of the material of the lens in the 1st lens group, it is minding as follows.

(i) About the pre-group, since the achromatism of paraxial is the need like the above-mentioned conditional expression, in order to carry out the primary achromatism, the difference of the Abbe number of a positive lens and a negative lens is enlarged. For example, the positive lens uses that to which the Abbe number exceeds 90. a typical thing -- a fluorite etc. -- high -- the anomalous scattering quality of the material is used. The negative lens uses conversely what has the small Abbe number for this. The difference of the Abbe number is as conditional expression (1). however, the Abbe number -- very much -- small -- in addition -- and the present condition is that what has the partial dispersion ratio Pgd of g line and d line close to the quality of the materials of high anomalous scattering, such as a fluorite, hardly exists.

(ii) The rear group which is a focal migration group arranges the negative lens from the body side to the 1st or the 2nd. Since this is a location where the axial ray incidence quantity h becomes the highest by the tele edge, it is one of reasons that it is a location suitable for practicing the achromatism for reducing the axial overtone aberration of a tele edge.

[0051] Then, the partial dispersion ratio Ppd of a negative lens is restricted like conditional expression (4). this is a negative lens and small air spacing -- it is -- the greatest effectiveness in the achromatism of a tele edge is mentioned by making it the combination of achromatism to which the Abbe number is 60 or more, and the partial dispersion ratio of a negative lens is equal to the positive lens which adjoins in the form of junction if possible with it using what has a comparatively large partial dispersion ratio.

[0052] Moreover, since the difference of the partial dispersion ratio of a positive lens and a negative lens will become remarkably large if the upper limit of conditional expression (4) is exceeded, it becomes the inclination for the effectiveness of reduction of the secondary spectrums in a tele edge to get worse.

(iii) the quality of the material in which, as for the positive lens following the combination of the negative lens and positive lens of a rear group, the Abbe number exceeds 54 similarly -- using -- in addition -- and the quality of the material which is a high refractive index if possible is used. This is for taking out the principal point as a front ball group in order to amend transverse chromatic aberration, such as a curvature of field by the side of a wide angle, and distortion, not to mention the spherical aberration of a tele edge and to make radius of curvature as loose as possible.

[0053] In this example, optical arrangement and the restriction of the front ball lens group F are determined as mentioned above. The so-called floating effectiveness can be acquired by satisfying these optical arrangement and restrictions.
[0054] Floating changes the include angle and height in which a beam of light passes air spacing of a certain arbitration in the lens group which moves in case the object distance changes and focuses by expanding or reducing according to delivery, and controls aberration fluctuation here.
[0055] Thus, in this example, the pre-group F11 of immobilization of the front ball lens group F and the rear group F12 for focal migration constituted, the quality of the material of power arrangement and a lens element and an aberration assignment were set up appropriately, and many aberration in the zoom whole region and the focal whole region especially spherical aberration, and axial overtone aberration are amended good.
[0056] In addition, when more than one exist about nu11, nu12, and nu21, a definition is given as the average.
[0057] By the way, it is not desirable to give refractive power comparatively strong against satisfying the above-mentioned conditions (3) to the negative lens LN12 in the rear group F12 which is a focal migration group. As for the lens configuration of this negative lens, under such a focal distance, it is desirable on aberration amendment to stop within the limits of conditional expression (5).
[0058] In being less than a lower limit in conditional expression (5) in relation to this conditional expression (3), the negative lens in a rear group has the strong refractive power of emission, and shows that the lens configuration where a periphery is very thick is carried out compared with a core. In such a case, the next demerit becomes remarkable.
(i) By optical arrangement of paraxial, if a negative lens with the strong refractive power of emission exists in a focal migration group to having explained by the comparison of the focal method of above-mentioned drawing 33 – drawing 36 , even if it is the inner focus method shown in drawing 35 , the include angle alpha which carries out outgoing radiation of the focal fixed group will become small, and the difference of hm-hf and hb-ha will become small. Therefore, though an inner focus method is adopted, it becomes difficult to make aberration fluctuation small.
(ii) If a negative lens with the refractive power of emission strong in a focal migration group exists, since it will become difficult to extrude the image side principal point of the 1st group which has forward refractive power as a whole, dead space increases from the time of the optical arrangement by paraxial, and a miniaturization becomes impossible.
(iii) If the thickness of a periphery becomes thick too much, since the height of the axial outdoor daylight line h which passes the effective aperture of a focal migration group to the limit by the wide angle side will become very high, a front ball diameter

becomes large and a miniaturization becomes difficult.

[0059] Conversely, in exceeding a upper limit in conditional expression (3) and (5), the negative lens in a rear group has the very weak refractive power of emission, and turns into a negative lens which does not almost have the difference of the thickness of a core and a periphery. In such a case, it not only becomes existence of only increasing dead-space, but the operation for the denial of aberration is almost lost and the difficulty of manufacture serves as an inclination which becomes high by leaps and bounds in processing of an actual lens.

[0060] Next, the zoom lens of this invention is satisfying conditional expression (6) in the front ball lens group (the 1st group) F first, in order to have a 14 to about 44 times zoom ratio and to realize diameter-ization of macrostomia throughout a zoom further. This uses the bright lens system. Although it will become a desirable direction to diameter[of macrostomia]-izing if a lower limit is exceeded, it becomes difficult to perform aberration amendment. If a upper limit is exceeded, it will become difficult to obtain a bright zoom lens.

[0061] Moreover, in consideration of the balance of a miniaturization of optical-character ability and the 1st lens group, it is necessary to restrict the focal distance Fc 12 of a rear group F12 under this conditional expression. In the zoom lens of which high optical-character ability is required like the zoom lens for broadcast, since an impossible miniaturization is attained and optical-character ability is not reduced, it is good for limit within the limits of conditional expression (7) to stop the focal distance of a rear group.

[0062] It is in the inclination which the path of the 1st lens group enlarges and is not desirable, while the optical power of a rear group will become weak and the movement magnitude in the case of a focus will become large, if a upper limit is exceeded. On the other hand, if a lower limit is exceeded, the optical power of a rear group will become strong and amendment of many aberration changed in a spherical-aberration list will become difficult.

[0063] By the way, especially in the formation of an inner focus, although the achromatism of only a pre-group F11 is enough about the achromatism which should be taken into consideration in a paraxial field, when actually making a lens heavy-gage, since the thickness of the whole 1st lens group F becomes very large, the error of the Miyoshi aberration to heavy-gage-izing will become large. Then, the achromatism for amending the error from the field in Miyoshi was needed, and conditional-expression (8) - (10) has prescribed. Both EF and EM are parameters which show the degree of achromatism, if it is ET=EM=0, the achromatism in the 1st group F will become sufficient thing, and the amount of the axial overtone aberration in a tele edge will decrease. As the technique of bringing EM close to EF and0, the focal distance of (i) each lens element is enlarged.

(ii) The Abbe number of the quality of the material of each lens element is enlarged.

(iii) A positive lens and a negative lens constitute the configuration of the lens element of each group, and it is negated.

Things are mentioned. However, the item of (i) disagrees with small [of the zoom lens whole system]. In fact, the Abbe number of the quality of the material has only about 20 to 95 width of face, and the item of (ii) is [the Abbe number] limited. Therefore (iii) becomes a means with the most effective item. it was difficult for especially the rear group that is a focal migration group in an inner focus method although the pre-group F11 was alike and easy to bring the value of EF close to 0 with the combination of a negative lens and a positive lens conventionally to be constituted by only two or more positive lenses from before, and to bring the value of EM close to 0. The aim which attains a miniaturization as much as possible having been one of reasons for having constituted the focal migration group only from a positive lens as for one, and especially another are because the secondary spectrum was level with few real use top problems in the tele edge. However, since the spatial frequency at the time of using a zoom lens when it comes to a high definition image like Hi-Vision will be 3 times the conventional method, it needs to carry out ultimate **** amendment especially of the chromatic aberration of a tele edge. Then, the achromatism in a pre-group F11 and a rear group 12 must be small amended, as shown in conditional expression (8) and (9).

[0064] Conditional expression (10) is a parameter which shows the denial of the degree of the achromatism of the whole front ball group as the 1st lens group F, i.e., the chromatic aberration of a pre-group and a rear group. It becomes insufficient amending [of the achromatism in a front ball group] that it is less than the lower limit of this conditional expression (10), it becomes conversely superfluous [achromatism] to exceed a upper limit, the excess and deficiency of achromatism arise for the amendment which cancels the excess and deficiency of the achromatism of a front ball group also in any optical system after BARIETA or case, and evils, like fluctuation of the chromatic aberration in a zoom middle region becomes large come out. That it is the same as that of this hits also to the interior of a front ball group, and it is ****. In conditional expression (8), if the value of EF is less than a lower limit, in order to negate the chromatic aberration in a front ball group, achromatism EM of a focal migration group tends to deny exceeding a upper limit. For this reason, as drawing 35 also explained, since the achromatism of a focal migration group is insufficient, in addition to change of the axial ray incidence quantity h in infinite distance and MOD, fluctuation by the focus of axial overtone aberration will become large.

[0065] On the contrary, if the value of EF serves as forward in conditional expression (8), the need that the achromatism of the focal migration group F12 serves as negative will come out. In order to make the value of EM negative, satisfying conditional expression (7), the need that a negative lens with the very strong refractive power of emission exists in a focal migration group comes out.

[0066] Next, the numerical example of this invention is shown. a numerical example -- setting -- Ri -- a body side -- the i-th lens thickness and air spacing, nickel, and nui are the radius of curvatures of the i-th lens side, and Di is the refractive index and the Abbe number of glass of the i-th lens in order from an each body side in a body side. In a numerical example, two or the three last RENSU sides are glass blocks, such as a face plate and a filter.

[0067] Moreover, the relation between the above-mentioned monograph affair type and many numeric values in a numerical example is shown in Table -1.

[0068] An aspheric surface configuration makes the travelling direction of H shaft and light forward to the X-axis, an optical axis, and a perpendicular direction in the direction of an optical axis, and is R Paraxial radius of curvature, K and A2, A3, A4, and A5 It is [0069] when it considers as an aspheric surface multiplier respectively.

[External Character 6]

$$X = \frac{(1/R)H^2}{1+\sqrt{1-(1+k)(H/R)^2}} + A_2 H^4 + A_3 H^6 + A_4 H^8 + A_5 H^{10}$$

It expresses with the becoming formula.

[0070]

[External Character 7]

〔数值実施例1〕

f=9.00　　fno=1:1.7～2.0　　2ω= 62.9° ～5.4°

r 1=	-899.355	d 1=	2.50	n 1= 1.76168	ν 1= 27.5	Pg′ d=1.31585
r 2=	110.946	d 2=	4.24			
r 3=	179.567	d 3=	10.43	n 2= 1.43985	ν 2= 95.0	Pg′ d=1.22944
r 4=	-162.561	d 4=	6.98			
r 5=	102.046	d 5=	2.00	n 3= 1.61673	ν 3= 43.8	Pg′ d=1.26305
r 6=	60.702	d 6=	0.02			
r 7=	60.679	d 7=	16.09	n 4= 1.62032	ν 4= 63.4	Pg′ d=1.24000
r 8=	-228.657	d 8=	0.15			
r 9=	-54.929	d 9=	5.77	n 5= 1.73234	ν 5= 54.7	Pg′ d=1.23988
r10=	105.402	d10=	可変			
r11=	53.206	d11=	0.80	n 6= 1.88814	ν 6= 40.8	
r12=	21.213	d12=	4.57			
r13=	-41.416	d13=	0.80	n 7= 1.82017	ν 7= 46.6	
r14=	24.709	d14=	3.23			
r15=	28.065	d15=	0.80	n 8= 1.83945	ν 8= 42.7	
r16=	20.728	d16=	5.00	n 9= 1.76260	ν 9= 25.1	
r17=	-45.909	d17=	0.80	n10= 1.88814	ν 10= 40.8	
r18=	103.594	d18=	可変			
r19=	-29.943	d19=	0.90	n11= 1.76077	ν 11= 47.8	
r20=	40.810	d20=	2.36	n12= 1.85501	ν 12= 23.9	
r21=	1201.272	d21=	可変			
r22=	(絞り)	d22=	1.10			
r23=	159.295	d23=	3.33	n13= 1.70558	ν 13= 41.2	
r24=	-60.388	d24=	0.20			
r25=	119.213	d25=	2.27	n14= 1.50349	ν 14= 56.4	
r26=	-1478.014	d26=	0.20			
r27=	74.499	d27=	6.29	n15= 1.50349	ν 15= 56.4	
r28=	-26.004	d28=	1.30	n16= 1.80811	ν 16= 46.6	
r29=	-114.378	d29=	28.00			
r30=	72.105	d30=	6.11	n17= 1.48915	ν 17= 70.2	
r31=	-40.249	d31=	0.20			
r32=	-92.459	d32=	1.40	n18= 1.83932	ν 18= 37.2	
r33=	46.430	d33=	6.75	n19= 1.50014	ν 19= 65.0	
r34=	-49.382	d34=	0.20			
r35=	86.161	d35=	6.49	n20= 1.48915	ν 20= 70.2	
r36=	-26.372	d36=	1.40	n21= 1.83945	ν 21= 42.7	
r37=	-177.791	d37=	0.20			
r38=	38.470	d38=	4.22	n22= 1.60548	ν 22= 60.7	
r39=	1675.041	d39=	4.10			
r40=	∞	d40=	30.00	n23= 1.60718	ν 23= 38.0	
r41=	∞	d41=	16.20	n24= 1.51825	ν 24= 64.2	
r42=	∞					

焦点距離 / 可変間隔	9.00	18.00	36.00	72.00	117.00
d 10	0.88	20.42	33.62	42.45	46.47
d 18	47.01	24.56	9.78	3.30	4.71
d 21	5.40	8.31	9.88	7.54	2.10

[0071]

[External Character 8]

〔数値実施例2〕

f=8.50 fno=1:1.7～2.1 2ω= 65.8° ～4.9°

r 1= -255.551		d 1= 2.50	n 1= 1.74553	ν 1= 31.7	Pg′ d=1.29828
r 2= 116.017		d 2= 3.32			
r 3= 159.478		d 3= 10.66	n 2= 1.43985	ν 2= 95.0	Pg′ d=1.22944
r 4= -169.489		d 4= 5.96			
r 5= 131.149		d 5= 2.20	n 3= 1.61669	ν 3= 44.2	Pg′ d=1.26190
r 6= 75.618		d 6= 0.02			
r 7= 75.377		d 7= 12.37	n 4= 1.43985	ν 4= 95.0	Pg′ d=1.22944
r 8= -525.485		d 8= 0.15			
r 9= 93.787		d 9= 10.38	n 5= 1.60520	ν 5= 65.5	Pg′ d=1.23561
r10= -299.830		d10= 0.15			
r11= 54.733		d11= 5.40	n 6= 1.73234	ν 6= 54.7	Pg′ d=1.23988
r12= 92.732		d12= 可変			
r13= 48.885		d13= 0.90	n 7= 1.88814	ν 7= 40.8	
r14= 17.522		d14= 4.68			
r15= -53.332		d15= 0.80	n 8= 1.82017	ν 8= 46.6	
r16= 25.118		d16= 4.28			
r17= 28.654		d17= 4.15	n 9= 1.82600	ν 9= 23.7	
r18= -53.487		d18= 0.59			
r19= -34.766		d19= 0.80	n10= 1.77621	ν10= 49.6	
r20= 88.499		d20= 可変			
r21= -27.616		d21= 0.90	n11= 1.77621	ν11= 49.6	
r22= 43.088		d22= 2.42	n12= 1.85501	ν12= 23.9	
r23= -481.564		d23= 可変			
r24=	(絞り)	d24= 1.10			
r25= 231.826		d25= 3.56	n13= 1.51977	ν13= 52.4	
r26= -46.618		d26= 0.20			
r27= 168.010		d27= 3.04	n14= 1.51977	ν14= 52.4	
r28= -81.919		d28= 0.20			
r29= 69.136		d29= 6.07	n15= 1.51977	ν15= 52.4	
r30= -30.903		d30= 1.30	n16= 1.82017	ν16= 46.6	
r31= -320.915		d31= 32.00			
r32= 49.972		d32= 6.30	n17= 1.48915	ν17= 70.2	
r33= -48.901		d33= 0.20			
r34= -289.282		d34= 1.40	n18= 1.83932	ν18= 37.2	
r35= 28.438		d35= 6.00	n19= 1.50349	ν19= 56.4	
r36= 782.437		d36= 0.20			
r37= 68.152		d37= 6.91	n20= 1.48915	ν20= 70.2	
r38= -25.893		d38= 1.40	n21= 1.83932	ν21= 37.2	
r39= -65.268		d39= 0.20			
r40= 40.256		d40= 4.43	n22= 1.51314	ν22= 60.5	
r41= -609.030		d41= 4.00			
r42= ∞		d42= 30.00	n23= 1.60718	ν23= 38.0	
r43= ∞		d43= 16.20	n24= 1.51825	ν24= 64.2	
r44= ∞					

焦点距離 / 可変間隔	8.50	17.00	34.00	68.00	127.50
d 12	0.80	19.24	31.64	39.85	44.35
d 20	44.49	23.25	9.39	3.47	6.23
d 23	6.20	8.99	10.45	8.17	0.80

[0072]

[External Character 9]

〔数値実施例3〕

f=8.00　　fno=1:1.7〜2.7　　2ω= 69.0° 〜3.9°

r		d	n	ν	Pg' d
r 1=	-200.224	d 1= 2.70	n 1= 1.85649	ν 1= 32.3	Pg' d=1.29992
r 2=	186.083	d 2= 6.51			
r 3=	455.997	d 3= 12.01	n 2= 1.43985	ν 2= 95.0	Pg' d=1.22944
r 4=	-127.284	d 4= 7.88			
r 5=	142.838	d 5= 2.50	n 3= 1.79013	ν 3= 44.2	Pg' d=1.26490
r 6=	99.498	d 6= 0.02			
r 7=	98.215	d 7= 15.15	n 4= 1.43985	ν 4= 95.0	Pg' d=1.22944
r 8=	-234.945	d 8= 0.20			
r 9=	114.271	d 9= 10.09	n 5= 1.60520	ν 5= 65.5	Pg' d=1.23561
r10=	-511.370	d10= 0.15			
r11=	59.804	d11= 6.26	n 6= 1.60520	ν 6= 65.5	Pg' d=1.23561
r12=	114.982	d12= 可変			
r13=	47.010	d13= 0.90	n 7= 1.88814	ν 7= 40.8	
r14=	16.663	d14= 6.70			
r15=	-56.863	d15= 0.80	n 8= 1.82017	ν 8= 46.6	
r16=	33.831	d16= 4.47			
r17=	29.158	d17= 5.32	n 9= 1.82600	ν 9= 23.7	
r18=	-52.029	d18= 0.90			
r19=	-31.823	d19= 0.80	n10= 1.75844	ν10= 52.3	
r20=	72.877	d20= 可変			
r21=	-29.012	d21= 0.75	n11= 1.77621	ν11= 49.6	
r22=	70.928	d22= 1.24	n12= 1.93301	ν12= 21.3	
r23=	-370.095	d23= 可変			
r24=	(絞り)	d24= 1.30			
r25=	263.190	d25= 4.11	n13= 1.62287	ν13= 60.3	
r26=	-54.541	d26= 0.18			
r27=	156.992	d27= 3.30	n14= 1.50014	ν14= 65.0	
r28=	-126.947	d28= 0.15			
r29=	47.125	d29= 7.68	n15= 1.50349	ν15= 56.4	
r30=	-40.483	d30= 1.50	n16= 1.83945	ν16= 42.7	
r31=	-252.408	d31= 28.00			
r32=	78.868	d32= 5.51	n17= 1.48915	ν17= 70.2	
r33=	-41.808	d33= 0.30			
r34=	-67.885	d34= 1.40	n18= 1.88814	ν18= 40.8	
r35=	23.625	d35= 7.81	n19= 1.51825	ν19= 64.2	
r36=	-67.344	d36= 0.20			
r37=	51.956	d37= 5.93	n20= 1.51314	ν20= 60.5	
r38=	-33.404	d38= 1.30	n21= 1.83945	ν21= 42.7	
r39=	-888.472	d39= 0.15			
r40=	35.701	d40= 5.19	n22= 1.51825	ν22= 64.2	
r41=	-78.383	d41= 4.50			
r42=	∞	d42= 30.00	n23= 1.60718	ν23= 38.0	
r43=	∞	d43= 16.20	n24= 1.51825	ν24= 64.2	
r44=	∞				

焦点距離 / 可変間隔	8.00	16.00	48.00	96.00	160.00
d 12	0.52	22.64	43.59	51.03	54.34
d 20	58.26	32.92	9.50	5.75	9.23
d 23	6.00	9.22	11.70	8.01	1.21

[0073]

[External Character 10]

〔数値実施例4－1〕

	f=10.00000		fno=1:1.8～4.0		2ω= 57.6° ～1.4°	
r 1=	258.310	d 1=	5.50	n 1= 1.83932	ν 1= 37.2	Pg′ d=1.28253
r 2=	147.470	d 2=	0.04			
r 3=	145.655	d 3=	18.52	n 2= 1.43496	ν 2= 95.1	Pg′ d=1.23247
r 4=	1788.734	d 4=	11.37			
r 5=	502.121	d 5=	11.81	n 3= 1.43496	ν 3= 95.1	Pg′ d=1.23247
r 6=	-540.542	d 6=	0.15			
r 7=	-525.580	d 7=	5.00	n 4= 1.77621	ν 4= 49.6	Pg′ d=1.24984
r 8=	-4050.532	d 8=	0.30			
r 9=	188.279	d 9=	18.58	n 5= 1.43496	ν 5= 95.1	Pg′ d=1.23247
r10=	-779.770	d10=	0.30			
r11=	144.762	d11=	11.15	n 6= 1.49845	ν 6= 81.6	Pg′ d=1.23153
r12=	333.208	d12= 可変				
r13=	337.087	d13=	2.00	n 7= 1.82017	ν 7= 46.6	
r14=	54.313	d14=	4.71			
r15=	-170.414	d15=	1.80	n 8= 1.77621	ν 8= 49.6	
r16=	50.612	d16=	6.91			
r17=	-66.371	d17=	1.80	n 9= 1.82017	ν 9= 46.6	
r18=	45.577	d18=	7.83	n10= 1.93306	ν 10= 21.3	
r19=	-346.002	d19= 可変				
r20=	9753.850	d20=	6.52	n11= 1.49845	ν 11= 81.6	
r21=	-113.140	d21=	0.30			
r22=	190.740	d22=	2.50	n12= 1.65223	ν 12= 33.8	
r23=	54.467	d23=	13.62	n13= 1.59143	ν 13= 61.2	
r24=	-152.092	d24=	0.20			
r25=	118.516	d25=	13.11	n14= 1.62032	ν 14= 63.4	
r26=	-76.404	d26=	2.50	n15= 1.85501	ν 15= 23.9	
r27=	-155.554	d27=	0.20			
r28=	89.671 (非球面)	d28=	3.78	n16= 1.48915	ν 16= 70.2	
r29=	168.002	d29= 可変				
r30=	(絞り)	d30=	3.29			
r31=	-52.660	d31=	1.80	n17= 1.79013	ν 17= 44.2	
r32=	33.435	d32=	4.19	n18= 1.81265	ν 18= 25.4	
r33=	142.254	d33=	6.15			
r34=	-44.772	d34=	1.60	n19= 1.73234	ν 19= 54.7	
r35=	30.867	d35=	10.72	n20= 1.59911	ν 20= 39.2	
r36=	-30.393	d36=	24.00			
r37=	400.206	d37=	5.96	n21= 1.48915	ν 21= 70.2	
r38=	-31.694	d38=	0.20			
r39=	-43.632	d39=	2.20	n22= 1.79013	ν 22= 44.2	
r40=	41.339	d40=	6.15	n23= 1.50349	ν 23= 56.4	
r41=	-49.159	d41=	1.10			
r42=	1051.682	d42=	6.15	n24= 1.55099	ν 24= 45.8	
r43=	-29.627	d43=	2.20	n25= 1.81265	ν 25= 25.4	
r44=	-83.226	d44=	0.20			
r45=	73.620	d45=	4.26	n26= 1.51977	ν 26= 52.4	
r46=	-74.825	d46=	5.00			
r47=	∞	d47=	50.00	n27= 1.51825	ν 27= 64.2	
r48=	∞					

非球面形状　参照球面　R=89.671

非球面係数　A=B=C=E=0　D=5.99704×10^{-14}

[0074]

[External Character 11]

〔数値実施例4－2〕

焦点距離 / 可変間隔	10.00	19.49	69.79	257.37	441.10
d 12	1.72	43.72	91.72	115.22	120.72
d 19	176.93	129.87	67.75	20.44	0.87
d 29	3.30	8.36	22.48	46.29	60.36

[0075]

[Table 1]

表-1

	数値実施例			
	1	2	3	4
$\nu_{11N}-\nu_{12P}$	-67.46	-63.31	-62.68	-57.93
$\nu_{11N}-\nu_{21N}$	-16.33	-12.58	-11.90	-12.43
f_{21}/F_{C12}	-3.728	-4.967	-6.366	-4.009
$(n_g-n_d)/(n_F-n_C)$	1.263	1.262	1.265	1.2498
$\left\lvert\frac{r_b+r_a}{r_b-r_a}\right\rvert$	3.936	3.723	5.591	1.298
FN1	1.197	1.054	1.198	1.696
$f_{C12}/F1$	0.948	0.925	0.942	1.038
EF	-2.269×10^{-4}	-2.402×10^{-4}	-2.297×10^{-4}	-3.527×10^{-5}
EM	2.300×10^{-4}	2.273×10^{-4}	1.885×10^{-4}	4.582×10^{-5}
EF/EM	-0.987	-1.056	-1.218	-0.770

[0076] Next, the description of each numerical example of this invention is explained.
[0077] The numerical example 1 shown in drawing 1 has a zoom ratio exceeding 13 times, and R1-R10 are the 1st lens groups F (the focal group F). Among these, R1-R4 are the focal fixed groups F11 which are immobilization and have power (refractive power) negative on the whole on the occasion of zooming and a focus. R5-R10 have power forward by the pre-group F12. It has power forward by nothing and the whole 1st lens group F for the 1st lens group F operation which has the operation which connects the object point to BARIETA V by R1-R10.
[0078] R11-R18 are BARIETAV which mainly contributes to variable power, moves to an image surface side in monotone on the occasion of the variable power to a call since wide, and passes one -1 time (actual size) the image formation scale factor of this on the way. R19-R21 are Compensators C, mainly have an operation of the image point amendment accompanying variable power, and also have a browning twice operation. Compensator C has forward power, and since wide, it moves to a body side in monotone from a wide angle edge criteria location on the occasion of the variable power to a call. SP (R22) is a diaphragm.
[0079] R23-R39 are the relay groups R which have an image formation operation, and R40-R42 are glass flocks equivalent to color-separation prism.
[0080] When the f number of a front ball lens group is defined as FN1=f1 (fT/FNT) as an index of diameter[of macrostomia]-izing, in this example, it is FN 1= 1.197.
[0081] To these diameters of macrostomia, and a power assignment, by the 1st lens group, have arranged one negative lens and one positive lens in the focal fixed group

for amendment of spherical aberration or axial overtone aberration, two positive lenses were made to use and share with a focal migration group, and it has amended.

[0082] Generally, the lens configuration of the front ball lens group F is as much as possible simple, and its one where the thickness of a block is smaller is desirable to small [of the zoom whole system], power-saving of a drive system, etc. For this reason, the front ball lens group F is wanted to lessen lens number of sheets as much as possible.

[0083] On the other hand, it becomes difficult for the f number FN1 of a front ball lens group to amend zooming, the spherical aberration by the focus, axial overtone aberration, etc., since it will become very bright and a power assignment of a front ball also becomes a strong thing in addition as mentioned above.

[0084] So, in this example, generating of spherical aberration and axial overtone aberration is suppressed using the negative lens with the very high refractive index of the quality of the material of a pre-group lens by using a positive lens with the very large Abbe number of the quality of the material for coincidence into a pre-group. At this time, the difference of the Abbe number of the quality of the material of the negative lens of a pre-group and a positive lens is nu11-nu12=-67.46.

[0085] The refractive power of the negative lens in the rear group FC12 at this time is f21/FC12=-3.728, and the partial dispersion ratio and shape factor of the quality of the material of this negative lens are (ng-nd)/(nF-nc)=1.263[0086], respectively.

[External Character 12]

$$\left|\frac{r_b+r_a}{r_b-r_a}\right| = 3.936$$

It has become.

[0087] Moreover, difference nu11-nu21 of the Abbe number of the quality of the material of the negative lenses which are the standards of an achromatism assignment of a pre-group and a rear group are nu11-nu21=-16.33.

[0088] The numerical example 2 shown in <u>drawing 2</u> has a zoom ratio exceeding 15 times, and R1-R12 are the 1st lens groups F (the focal group F). Among these, R1-R4 are the focal fixed groups F11 which are immobilization on the occasion of zooming and a focus, and have power (refractive power) forward on the whole, and R5-R12 have power forward with the rear group F12 which is a focal migration group. It has power forward by nothing and the whole front ball lens group F for an operation of the front ball lens group F which has the operation which connects the object point to BARIETA V by R1-R12.

[0089] R13-R20 are PARIETAV which mainly contributes to variable power, moves to an image surface side in monotone on the occasion of the variable power to a call since wide, and passes one -1 time (actual size) the image formation scale factor of this on the way. It has negative power, and since the compensator C which mainly has

an operation of the image point amendment accompanying variable power is wide, it moves to a body side from a wide angle edge criteria location on the occasion of the variable power to a call, and R21-R23 are compensators, and it exists [it moves to an image side from a certain focal distance, and] in an image side rather than a wide angle edge criteria location by the tele edge. SP (R24) is a diaphragm.

[0090] R25-R41 are the relay groups R which have an image formation operation, and R42-R44 are glass blocks equivalent to color-separation prism.

[0091] Compared with the numerical example 1, the zoom ratio has attained field angle 2omega=65.8 degree of a wide angle edge with 15 times and a high scale factor.

[0092] In order to attain this wide angle-ization, it is necessary to amend many aberration greatly influenced by the field angle, such as distortion aberration and the chromatic aberration of magnification, good. Moreover, the front ball f number is FN 1= 1.054 and a very bright thing.

[0093] So, one negative lens and three positive lenses constitute the rear group which is a focal migration group from this example. And by setting difference nu11-nu21 of the Abbe number of each negative lens of a pre-group and a rear group to -12.58, good chromatic-aberration amendment is performed in spite of the wide angle. Moreover, also in the rear group, by making comparatively high the refractive index of the quality of the material of the positive lens by the side of the image surface among three positive lenses, though spherical aberration and distortion aberration are amended good, it is considering as optical arrangement which contributes to chromatic-aberration amendment.

[0094] the numerical example 3 of drawing 3 -- the numerical example 2 -- comparing -- abbreviation -- though it is the same lens configuration, suitable selection of power arrangement has attained wide-angle-izing and high variable power-ization further, and a zoom ratio is 20 times.

[0095] And in order to attain miniaturization to coincidence, the movement magnitude in the case of the variable power of BARIETA V and Compensator C is strongly reduced for the power assignment of each lens group.

[0096] For this reason, the f number of the 1st lens group is 1.198 and a severe thing. In addition, the retro ratio of the 1st lens group must be raised for the further wide-angle-izing. Moreover, since the focal distance of a tele edge also amounts to 160mm, amendment of a tele edge, especially chromatic aberration becomes difficult.

[0097] So, in this example, a pre-group and a rear group have a comparatively high refractive index, a negative lens with the very small Abbe number and a positive lens with the very big Abbe number constitute them, nu11-nu12 set to -62.68, and nu11-nu21 are setting them to -11.90. And by giving the achromatism of a pre-group further to a rear group, fluctuation of many aberration is suppressed good throughout a zoom and the focus.

[0098] Moreover, fluctuation of many aberration especially by the focus is suppressed

good by constituting the rear group with three positive lenses like examples 2 and 3. By having increased the degree of freedom of a design of a focal migration group, this only not only in (i) spherical aberration Since the width of face of selection of the quality of the material of (ii) lens element which is raising resolution especially among optical-character ability since a leeway is given also in fluctuation amendment of other astigmatism etc. becomes large Especially the very big positive lens of the Abbe number is adopted, the achromatism of a focal migration group is raised, fluctuation of chromatic aberration is reduced, and the effectiveness of reducing color blots of an image is drawn.

[0099] the numerical example 4 shown in drawing 4 -- the field angle of a wide angle edge -- 2 -- although it is about omega= 57.6 degrees, there is a zoom ratio also 44 times and the field angle of a tele edge is called 2omega=1.4 degree -- extraordinary -- high -- it is a scale factor zoom lens.

[0100] Since the focal distance of a tele edge is very long, it becomes difficult amendment of spherical aberration and to amend [of axial overtone aberration] this example. For a certain reason, amendment of zoom fluctuation of many aberration is also still difficult for coincidence also a zoom ratio and 44 times.

[0101] So, in this example, in spite of not being a wide angle zoom like the numerical example 3, a negative lens with a comparatively high refractive index and three positive lenses constitute a focal migration group first, and the same effectiveness as the numerical example 3 is drawn. Next, the aspheric surface is given to R28 page among Compensators C, and especially the spherical aberration by the side of looking far is amended. And the focal fixed group is raising achromatism from the first by arranging the positive lens element of the quality of the material with the very large Abbe number also in a focal migration group. Aberration amendment is performed so that high optical-character ability can be obtained also in the tele edge of super-****** by such technique.

[0102] The negative lens in a rear group is the negative meniscus lens of concave at the body side, and it is mainly made effective [the negative lens] against axial outdoor daylight line aberration amendments, such as a curvature of field and distortion, furthermore.

[0103] At this time, it is nu11-nu12=-57.93 and nu11-nu21=-12.43, and the secondary spectrum of the axial overtone aberration of a tele edge is decreased especially by leaps and bounds. Although the axial overtone aberration of the tele edge in the 4th example is 3 times [no less than] the focal distance of other tele edges of the 1st - the 3rd example, the amount of secondary spectrums is amended almost equally.

[0104]

[Effect of the Invention] While setting up appropriately refractive power, an f number value, etc. of a front ball group in the so-called 4 group zoom lens as mentioned above according to this invention By dividing a front ball lens group into a focal fixed group

and a focal migration group, and taking a division method with which are satisfied of the predetermined conditions of arrangement of lens EMERENTO, a refractive-power assignment, and an achromatism assignment Fluctuation of variable power and the spherical aberration accompanying focusing, and chromatic aberration is lessened. furthermore, the about 1.7 f number of a wide angle edge with [amend fluctuation of transverse chromatic aberration, such as astigmatism accompanying variable power, and a curvature of field, with sufficient balance, and] high optical-character ability over all variable power range and all focal range and a variable power ratio -- the zoom lens of a high variable power ratio can be attained by about 13 to 44 diameter ratio of macrostomia.

[0105] Moreover, the same effectiveness is acquired even if it applies this invention to the zoom lens which moves some relays according to variable power.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The lens sectional view of the wide angle edge of the numerical example 1 of this invention.

[Drawing 2] The lens sectional view of the wide angle edge of the numerical example 2 of this invention.

[Drawing 3] The lens sectional view of the wide angle edge of the numerical example 3 of this invention.

[Drawing 4] The lens sectional view of the wide angle edge of the numerical example 4 of this invention.

[Drawing 5] The aberration Fig. of the focal distance f= 9.0 of the numerical example 1 of this invention, and 3.0m of object distances.

[Drawing 6] The aberration Fig. of the focal distance f= 18.0 of the numerical example 1 of this invention, and 3.0m of object distances.

[Drawing 7] The aberration Fig. of the focal distance f= 36.0 of the numerical example 1 of this invention, and 3.0m of object distances.

[Drawing 8] The aberration Fig. of the focal distance f= 72.0 of the numerical example 1 of this invention, and 3.0m of object distances.

[Drawing 9] The aberration Fig. of the focal distance f= 117.0 of the numerical example 1 of this invention, and 3.0m of object distances.

[Drawing 10] The focal distance f= 117.0 of the numerical example 1 of this invention, the aberration Fig. of object distance infinity.

[Drawing 11] The aberration Fig. of the focal distance f= 117.0 of the numerical example 1 of this invention, and 0.9m of object distances.

[Drawing 12] The aberration Fig. of the focal distance f= 8.5 of the numerical example 2 of this invention, and 3.0m of object distances.

[Drawing 13] The aberration Fig. of the focal distance f= 17.0 of the numerical example 2 of this invention, and 3.0m of object distances.

[Drawing 14] The aberration Fig. of the focal distance f= 34.0 of the numerical example 2 of this invention, and 3.0m of object distances.

[Drawing 15] The aberration Fig. of the focal distance f= 68.0 of the numerical example 2 of this invention, and 3.0m of object distances.

[Drawing 16] The aberration Fig. of the focal distance f= 127.5 of the numerical example 2 of this invention, and 3.0m of object distances.

[Drawing 17] The focal distance f= 127.5 of the numerical example 2 of this invention, the aberration Fig. of object distance infinity.

[Drawing 18] The aberration Fig. of the focal distance f= 127.5 of the numerical example 2 of this invention, and 0.9m of object distances.

[Drawing 19] The aberration Fig. of the focal distance f= 8.0 of the numerical example 3 of this invention, and 3.0m of object distances.

[Drawing 20] The aberration Fig. of the focal distance f= 16.0 of the numerical example 3 of this invention, and 3.0m of object distances.

[Drawing 21] The aberration Fig. of the focal distance f= 48.0 of the numerical example 3 of this invention, and 3.0m of object distances.

[Drawing 22] The aberration Fig. of the focal distance f= 96.0 of the numerical example 3 of this invention, and 3.0m of object distances.

[Drawing 23] The aberration Fig. of the focal distance f= 160.0 of the numerical example 3 of this invention, and 3.0m of object distances.

[Drawing 24] The focal distance f= 160.0 of the numerical example 3 of this invention, the aberration Fig. of object distance infinity.

[Drawing 25] The aberration Fig. of the focal distance f= 160.0 of the numerical example 3 of this invention, and 0.9m of object distances.

[Drawing 26] The aberration Fig. of the focal distance f= 10.0 of the numerical example 4 of this invention, and 10.0m of object distances.

[Drawing 27] The aberration Fig. of the focal distance f= 19.49 of the numerical example 4 of this invention, and 10.0m of object distances.

[Drawing 28] The aberration Fig. of the focal distance f= 69.79 of the numerical example 4 of this invention, and 10.0m of object distances.

[Drawing 29] The aberration Fig. of the focal distance f= 257.37 of the numerical example 4 of this invention, and 10.0m of object distances.

[Drawing 30] The aberration Fig. of the focal distance f= 441.10 of the numerical example 4 of this invention, and 10.0m of object distances.

[Drawing 31] The focal distance f= 441.10 of the numerical example 4 of this invention, the aberration Fig. of object distance infinity.

[Drawing 32] The aberration Fig. of the focal distance f= 441.10 of the numerical example 4 of this invention, and 3.4m of object distances.
[Drawing 33] The explanatory view of paraxial refractive-power arrangement of the 1st group of the conventional 4 group zoom lens.
[Drawing 34] The lens sectional view of the 1st group of the conventional 4 group zoom lens.
[Drawing 35] The explanatory view of paraxial refractive-power arrangement of the 1st group of the conventional 4 group zoom lens.
[Drawing 36] The lens sectional view of the 1st group of the conventional 4 group zoom lens.

[Description of Notations]

F The 1st group (focal group)
F11 Focal fixed group
F12 Focal migration group
V The 2nd group (BARIETA)
C The 3rd group (compensator)
R The 4th group (relay group)
G Glass block
SP Diaphragm
e e line
g g line
deltaS Sagittal image surface
deltaM Meridional image surface

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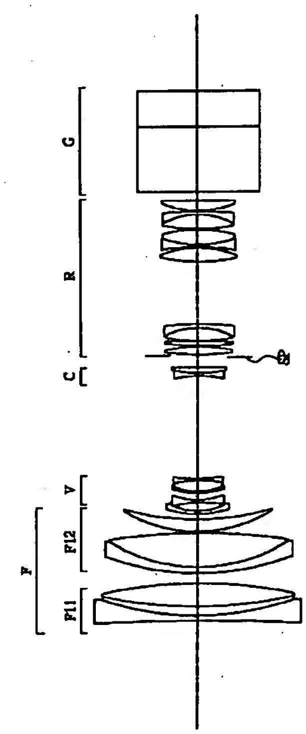
(54)【発明の名称】　ズームレンズ

(57)【要約】

【目的】　４群構成のズームレンズにおけるフォーカス作用を司る第１レンズ群の構成を工夫して、諸収差、特に球面収差並びに色収差の少ないズームレンズを提供すること。

【構成】　ズームレンズの第１レンズ群を固定の前群とフォーカス時に移動する後群とに分け、前記前群を少なくとも１つの負レンズＬＮ１１を少なくとも１つの正レンズＬＰ１２の独立した２つのレンズで構成し、前記後群を物体側より１番目あるいは２番目に配置される少なくとも１つの負レンズＬＮ２１と少なくとも２つの正レンズで構成し、各レンズの諸要素を適切に定めること。



【特許請求の範囲】

【請求項1】 物体側より順に正の屈折力の第1レンズ群、変倍用の負の屈折力の第2レンズ群、変倍に伴う像面変動を補正する第3レンズ群、そして結像作用を有する第4レンス群とを有したズームレンズにおいて、該第1レンズ群は合焦時固定の前群と正の屈折力を有し無限遠物体から至近物体への合焦時に物体側へ移動する後群とから成り、前記前群は少なくとも1つの負レンズLN11と少なくとも1つの正レンズLP12の独立した2つのレンズを有し、前記後群は、物体側より1番目あるいは2番目に配置される少なくとも1つの負レンズLN21と少なくとも2つの正レンズを有しており、前記後群の焦点距離をFc12、前記負レンズLN11と正レンズLP12の材質のアッベ数を各々ν_{11N}，ν_{12P}、前記負レンズLN21の焦点距離と材質のアッベ数を各々f21，ν_{21N}としたとき

$\nu_{11N}-\nu_{12P}<-55$

$\nu_{11N}-\nu_{21N}<-10$

$-6.5<f21/Fc12<-3.5$

なる条件を満足することを特徴とするズームレンズ。

【請求項2】 該負レンズLN21の材質の屈折率のうち、d線（波長587．56nm）、g線（波長435．83nm），F線（波長486．13nm）、C線（波長656．27nm）のものを各々nd，ng，nF，ncとしたとき、

$Pgd=(ng-nd)/(nF-nc)<1.36-0.00208\times\nu_{21}$

なる条件を満足することを特徴とする請求項1のズームレンズ。

【請求項3】 該負レンズLN21の物体側と像面側のレンズ面の曲率半径を各々ra，rbとしたとき、

【外1】

$$1.1<\left|\frac{r_b+r_a}{r_b-r_a}\right|<5.6$$

なる条件を満足することを特徴とする請求項1のズームレンズ。

【請求項4】 望遠端における全系の焦点距離とFナンバーを各々FT，FNT、該第1レンズ群の焦点距離をF1としたとき、

$1.0<FN1<1.7$

但し、$FN1=F1/(FT/FNT)$

$0.9<F_{C12}/F1<1.1$

なる条件を満足することを特徴とする請求項1のズームレンズ。

【請求項5】 前記第11群の第i番目のレンズの焦点距離と材質のアッベ数を各々f11i，ν11i，前記第12群の第i番目のレンズの焦点距離と材質のアッベ数を各々f12i，ν12iとしたとき

【外2】

$-2.5\times10^{-4}<EF\leq0$ 　　但し $EF=\Sigma\frac{1}{f11i\times\nu11i}$

$0\leq EM<2.4\times10^{-4}$ 　　但し $EM=\Sigma\frac{1}{f12i\times\nu12i}$

$-1.28<EF/EM<-0.75$

なる条件を満足することを特徴とする請求項1のズームレンズ。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明はテレビカメラ、ビデオカメラ、写真用カメラ等に好適なズームレンズに関し、特に第1群中の一部のレンズ群でフォーカスを行なう、所謂インナーフォーカス式を用いた至近物体距離の短い広角端のFナンバー1．7、ズーム比13～44程度の大口径、高変倍比のズームレンズに関するものである。

【0002】

【従来の技術】従来よりテレビカメラ等のズームレンズにはテレビカメラの小型化に伴い、レンズ系全体が小型で、しかも大口径比、高変倍比のものが要望されている。

【0003】ズームレンズとして変倍レンズ群より物体側に位置するレンズ群によりフォーカシング（合焦）を行う方式では、ズーミング（変倍）とフォーカシングが独立に行えるため、移動のための機構を簡略化でき、ズーミングによるピント移動が生じず、一定の物体距離に対してはズーム位置に依らず一定の繰り出し量でフォーカシングを行えるという特長を有している。

【0004】このようなズームレンズのうち物体側から順に合焦用の正の屈折力の第1群（合焦レンズ群）、変倍用の負の屈折力の第2群（変倍レンズ群）、変倍に伴って変動する像面を補正する為の正又は負の屈折力の第3群（補正レンズ群）、開口絞り、そして結像用の正の屈折力の第4群（リレーレンズ群）の4つのレンズ群より成る所謂4群ズームレンズにおいて、第1群中の一部のレンズ群を移動させてフォーカスを行なう、所謂インナーフォーカス式を採用したものが、例えば特公昭59－4686号公報で提案されている。

【0005】同公報では第1群を負の屈折力の第11群、正の屈折力の第12群そして正の屈折力の第13群の3つのレンズ群より構成し、無限遠物体から至近距離物体にかけてのフォーカスを第12群を像面側へ移動させて行なっている。

【0006】又、特開昭52－109952号公報、特開昭55－57815号公報、特開昭55－117119号公報、特公昭61－53696号公報、特公昭52－41068号公報等では、4群ズームレンズにおいて第1群を複数のレンズ群に分割し、そのうち最も物体側のレンズ群をフォーカシング時に固定とし、それより後方の像面側のレンズ群の一部をフォーカシング時に移動させるインナーフォーカシングとしている。

【０００７】又、特開昭５２－１２８１５３号公報では第１群を２つのレンズ群に分割し、その２つのレンズ群の間隔を無限遠物体から有限距離物体へのフォーカシングに際し、大きくなるように移動させフォーカシングを行っている。

【０００８】一般にインナーフォーカス式のズームレンズは第１群全体を移動させてフォーカスを行なうズームレンズに比べて第１群の有効径が小さくなり、レンズ系全体の小型化が容易となり、又近接撮影、特に極近接撮影が容易となり、更に比較的小型計量のレンズ群を移動させて行なっているのでレンズ群の駆動力が小さくてすみ、迅速な焦点合わせができる等の特長を有している。

【０００９】

【発明が解決しようとする課題】ズームレンズにおいて大口径比（例えばＦナンバー１．７～３．３）、高変倍比（例えば変倍比１３～４４程度）で、しかも全変倍範囲及び全フォーカス範囲にわたり高い光学性能を得るに各レンズ群の屈折力（パワー）やレンズ構成、そして色消分担等を適切に設定する必要がある。

【００１０】一般に全変倍範囲及び全フォーカス範囲にわたり収差変動が少なく高い光学性能を得るには、例えば各レンズ群のパワーを小さくして各レンズ群で発生する収差量を小さくするか、各レンズ群のレンズ枚数を増加させて収差補正上の自由度を増やすことが必要となってくる。このため大口径比で高変倍比のズームレンズを達成しようとすると、どうしても各レンズ群間の空気間隔が大きくなったり、レンズ枚数が増加するなどして、レンズ系全体が重厚長大化してくるという問題点が生じてくる。

【００１１】又、最近の放送用ズームレンズにおいては、より広角化、より高変倍比化が望まれており、更に近距離性能の向上やＭ．Ｏ．Ｄ（最短撮影距離）の短縮が、仕様上、映像効果上、重要な要素の１つとなりつつある。

【００１２】しかしながら、放送用ズームレンズにおいてはフォーカシングによる諸収差の変動、特に球面収差、軸上色収差、非点収差等の変動が顕著で光学性能を良好に維持するのが大変難しかった。このときの収差変動は、一般に焦点距離が大きい程、Ｆナンバーが小さく大口径比な程、そしてＭ．Ｏ．Ｄが短い程、大きくなる傾向があった。

【００１３】前述のフォーカシング方式についていえば、特開昭５２－１０９９５２号公報、特開昭５５－５７８１５号公報、特開昭５５－１１７１１９号公報のズームレンズでは収差補正上、第１群の構成レンズ枚数が多いため、レンズ全系が大型化、複雑化し、重量も重くなってしまう。

【００１４】特公昭６１－５３６９６号公報のズームレンズでは、第１群は比較的簡易な構成となっているが、無限遠フォーカス時の第１群と変倍レンズ群との空気間隔が大きく開いており、更に近距離フォーカス時に負の屈折力のフォーカス群が像面側へ移動するため、広角側での軸外光線の高さが第１群にて高くなり、レンズ系が大型化してしまう。

【００１５】第１群の繰り出し方式のズームレンズでは、第１群は比較的簡易な構成にでき小型化に適するが、特にフォーカシングによる球面収差、軸上色収差の変動が大きくなってくる。例えば、近距離フォーカスになるにつれて球面収差はアンダーへ倒れ、軸上色収差もアンダーとなる。

【００１６】以下にこのときの収差変動のメカニズムについて説明する。

【００１７】図３３は第１群を負の屈折力の第１１群Ｌ１１と正の屈折力の第１２群Ｌ１２で構成したときの薄肉近軸系の説明図である。図３４は４群ズームレンズにおける代表的な第１群Ｌ１のレンズ断面図である。

【００１８】図３３において、実践が無限遠物体フォーカス時の位置、点線がＭ．Ｏ．Ｄ時の位置である。実践で示す無限遠フォーカス時の近軸光線の第１１群と第１２群への入射高を各々ｈａ，ｈｂ、第１１群と第１２群間の傾角をａ、点線で示すＭ．Ｏ．Ｄ時の近軸光線の第１群と第２群への入射高を各々ｈａ′，ｈｂ′、第１１群と第１２群間の傾角をａ′とするとａ′＜ａであるから、

ｈｂ－ｈａ＜ｈｂ′－ｈａ′

である。

【００１９】ここで３次収差理論では軸上色収差の３次収差係数Ｌは近軸光線高ｈの２乗に比例し、球面収差の３次収差係数Ｉは近軸光線高ｈの４乗に比例する。このフォーカス方式では無限遠物体時よりＭ．Ｏ．Ｄ時の方が係数Ｌはプラス方向に大きくなるため軸上色収差はアンダーへ、係数Ｉも同様にプラス方向に大きくなるため球面収差もアンダーへ変動する。

【００２０】特公昭５２－４１０６８号公報のズームレンズでは、図３６に示すように第１群を２つのレンズ群に分割し、そのうち物体側の第１１群Ｌ１１に略ノーパワーの弱い負の屈折力を持たせフォーカシングに際し固定とし、像面側の正の屈折力の第１２群Ｌ１２を移動させることによりフォーシングを行なっている。

【００２１】これを第１１群と第１２群の薄肉近軸系とし図３５に示す。図３５に示すように第１２群については、その主点の移動として示している。

【００２２】実線が無限遠物体のフォーカス時の近軸光線で、このときの第１１群、第１２群への入射高を各々ｈｆ，ｈｍ、点線で示すＭ．Ｏ．Ｄ時の金属光線の第１１群と第１２群への入射高を各々ｈｆ′，ｈｍ′とすれば図３３（第１群繰り出し方式）と比較して、

ｈｂ－ｈａ＜ｈｍ－ｈｆ

ｈｂ′－ｈａ′≒ｈｍ′－ｈｆ′

である。

【００２３】従って同公報のズームレンズによれば、第１群の繰り出し方式に比べて、無限遠時からＭ．Ｏ．Ｄ時までの３次の球面収差係数Ｉ及び軸上色収差係数Ｌの変化量を小さくすることが可能となる。よって第１群の繰り出し方式よりも、フォーカシングによる球面収差、軸上色収差の変動を減少させることができる。しかしながら依然として、その変動量は満足できるものではなく、更なる改善が望まれている。

【００２４】特開昭５２－１２８１５３号公報のズームレンズでは、第１群を２つのレンズ群に分割し、その双方をフォーカシング時に移動させ、その２つのレンズ群の間隔を近距離フォーカスになるに従い大きくすることにより主に周辺性能を改善している。しかし、実施例によると近距離フォーカス時に球面収差もアンダーに倒れており、中心性能は逆に悪化している。

【００２５】このことに加えて一般に最近のユーザーの要望であるズームレンズ全体の小型軽量化を達成しつつ高仕様化を図るには各レンズ群の屈折力やレンズ構成を適切に設定する必要がある。特に４群ズームレンズにおいては、レンズ全系の大きさと重量を最も左右する第１群（前玉群）が分担する屈折力とレンズ群の明るさは重要な要素になっている。

【００２６】更には、ハイビジョンのような高精細な放送方式において、ズーム，フォーカス全域にて高い光学性能を得るためには、特にズームの望遠側やフォーカスによる収差変動を抑制しなければならない。このうち特に軸上色収差や倍率色収差の変動や収差量の絶対値そのものを極力抑制しなければ高い解像力を得ることができなくなってきている。このため、望遠端側の収差やフォーカスによる収差に大きく関与する第１群（前玉群）をいかに構成させるかが重要な要素となってきている。

【００２７】そして、本発明は４群ズームレンズを構成するフォーカス用の第１群の一部のレンズ群を光軸上移動させてフォーカスを行なうインナーフォーカス方式を採用しつつ、大口径化及び高変倍化を図る際、各レンズ群のレンズ構成を適切に設定することにより、変倍及びフォーカシングに伴う球面収差、色収差等の諸収差の変動を減少させ、全変倍範囲及び全フォーカス範囲にわたり高い光学性能を有した広角端のＦナンバー１．７程度、変倍比１３～４４程度の大口径比かつ高変倍比のズームレンズの提供を目的とする。

【００２８】

【課題を解決するための手段及び作用】本発明のズームレンズは、物体側より順に正の屈折力の第１レンズ群、変倍用の負の屈折力の第２レンズ群、変倍に伴う像面変動を補正する正又は負の屈折力の第３レンズ群、そして結像作用を有する第４レンズ群とを有したズームレンズにおいて、該第１レンズ群は合焦時固定の前群と無限遠物体から至近物体への合焦時に物体側へ移動する後群とから成り、前記前群は少なくとも１つの負レンズＬＮ１１と少なくとも１つの正レンズＬＰ１２の独立した２つのレンズを有し、前記後群は、物体側より１番目あるいは２番目に配置される少なくとも１つの負レンズＬＮ２１と少なくとも２つの正レンズを有しており、前記後群の焦点距離をＦｃ１２、前記負レンズＬＮ１１と正レンズＬＰ１２の材質のアッベ数を各々ν_{11N}，ν_{12P}、前記負レンズＬＮ２１の焦点距離と材質のアッベ数を各々ｆ２１，ν_{21N}としたとき

$\nu_{11N}-\nu_{12P}<-55$…（1）

$\nu_{11N}-\nu_{21N}<-10$…（2）

$-6.5<f21/Fc12<-3.5$…（3）

なる条件を満足することを特徴としている。

【００２９】その他本発明の請求項２では、前記負レンズＬＮ２１の材質のうち、ｄ線（波長５８７．５６ｎｍ）、ｇ線（波長４３５．８３ｎｍ），Ｆ線（波長４８６．１３ｎｍ），Ｃ線（波長６５６．２７ｎｍ）のものを各々ｎｄ，ｎｇ，ｎＦ，ｎｃとしたとき、

$$Pgd=(ng-nd)/(nF-nc)<1.36-0.00208\times\nu_{21}\cdots(4)$$

なる条件を満足すること、前記負レンズＬＮ２１の物体側と像面側のレンズ面の曲率半径を各々ｒａ，ｒｂとしたとき、

【００３０】

【外３】

$$1.1<\left|\frac{r_b+r_a}{r_b-r_a}\right|<5.6\quad\cdots(5)$$

なる条件を満足すること、望遠端における全系の焦点距離とＦナンバーを各々ＦＴ，ＦＮＴ、該第１レンズ群の焦点距離をＦ１としたとき、

$1.0<FN1<1.7$…（6）

但し、$FN1=F1/(FT/FNT)$

$0.9<F_{C12}/F1<1.1$…（7）

なる条件を満足すること、前記第１１群の第ｉ番目のレンズの焦点距離と材質のアッベ数を各々ｆ１１ｉ，ν１１ｉ，前記第１２群の第ｉ番目のレンズの焦点距離と材質のアッベ数を各々ｆ１２ｉ，ν１２ｉとしたとき

【００３１】

【外４】

$$-2.5\times10^{-4}<EF\leq0 \quad 但し EF=\Sigma\frac{1}{f11i\times\nu11i} \quad \cdots(8)$$

$$0\leq EM<2.4\times10^{-4} \quad 但し EM=\Sigma\frac{1}{f12i\times\nu12i} \quad \cdots(9)$$

$$-1.28<EF/EM<-0.75 \quad \cdots(10)$$

なる条件を満足することを特徴としている。

【００３２】

【実施例】図１，図２，図３，図４は各々本発明の数値実施例１，２，３，４の広角端におけるレンズ断面図である。図５～図１１は本発明の数値実施例１の収差図、図１２～図１８は本発明の数値実施例２の収差図、図１９～図２５は本発明の数値実施例３の収差図、図２６～図３２は本発明の数値実施例４の収差図である。

【００３３】図１～図４において、Ｆは正の屈折力の第１レンズ群（前玉レンズ群）であり、固定の前群Ｆ１１とフォーカス用の正の屈折力の後群Ｆ１２の２つのレンズ群より成っている。前群Ｆ１１は少なくとも１つの負レンズＬＮ１１と、少なくとも１つの正レンズＬＰ１２の独立した２つのレンズを有している。後群Ｆ１２は物体側より１番目あるいは２番目に配置される少なくとも１つの負レンズＬＮ２１と、少なくとも２つの正レンズを有している。無限遠物体から至近距離物体へのフォーカスは後群Ｆ１２を物体側へ移動させて行なっている。

【００３４】Ｖは第２群としての変倍用の負の屈折力のバリエータであり、光軸上像面側へ単調に移動させることにより、広角端（ワイド）から望遠端（テレ）への変倍を行なっている。第２群Ｖは変倍の際に結像倍率が等倍（－１倍）を含む領域内で変化させている。

【００３５】Ｃは第３群としての正又は負の屈折力のコンペンセータであり、変倍に伴う像面変動を補正するために移動している。Ｓ.Ｐは絞り、Ｒは第４群としての正の屈折力のリレー群である。Ｇは色分解プリズムや光学フィルター等であり、同図ではガラスブロックとして示している。

【００３６】一般に４群ズームレンズにおいて最も物体側の第１群全体で焦点合わせを行なう、所謂前玉フォーカス方式は各焦点距離において同一物体距離に対しては第１群の繰り出し量が一定となるため、レンズ鏡筒構造が簡単になるという特長がある。

【００３７】しかしながら第１群が正の屈折力を有し、広画角を含むズームレンズにおいては広角端において至近距離物体に焦点合わせをする際、第１群が物体側へ移動するため軸外光束を確保するために第１群の有効径が増大し、また比較的重量の重い第１群を移動させるため駆動トルクが増大し、迅速なる合焦が難しくなってくる。

【００３８】そこで本発明においては前述の構成を有し、かつ条件式を満足するズームレンズにおいて、無限遠物体から至近距離物体への焦点合わせを前群Ｆ１１を固定とし、後群Ｆ１２を物体側へ移動させて行なうインナーフォーカス方式を採用することによって第１群Ｆのレンズ有効径の増大を防止し、レンズ系全体の小型化を図り、更に至近距離の短縮化を図っている。

【００３９】更にこの固定の前群Ｆ１１は物体側より順に少なくとも１つの負レンズＬＮ１１と比較的小さな空間間隔を隔てて少なくとも１つの正レンズＬＰ１２とにより構成している。

【００４０】この固定の前群Ｆ１１においては、負レンズＬＮ１１と正レンズＬＰ１２の材質のアッベ数の差を条件式（１）の如くその差を大きく、又前群の負レンズＬＮ１１と後群の負レンズＬ２１のアッベ数の差を条件式（２）の如く負レンズＬ２１のアッベ数を大きく設定している。これによりズーミング或いはフォーカシングによる色収差の変動を良好に補正している。

【００４１】加えて、負レンズＬＮ１１と正レンズＬＰ１２を接合レンズとすることをせず、比較的小さな空気間隔を隔てて配置している。この空気間隔を挟んだ負レンズＬＮ１１の像面側のレンズ面の曲率半径と正レンズＬＰ１２の物体側のレンズ面の曲率半径により成る空間、所謂空気レンズは略等しい曲率半径が物体側に凸状の正メニスカスレンズ形状に構成している。

【００４２】この空気レンズを構成することにより、

（ａ）設計の自由度が増加することにより、収差補正の分担が軽減される。

（ｂ）各収差の急激な加減ができるため、特に高次収差のコントロールが簡易となる。

（ｃ）負レンズＬＮ１１が離れるため、前玉レンズ群の主点を押し出すため小型化に寄与する。

等の効果を引き出している。

【００４３】更にフォーカス移動群である後群Ｆ１２は、物体側より１番目あるいは２番目に配置される少なくとも１つの負レンズと少なくとも２つの正レンズを有しており、高変倍及び短いＭＯＤに対応して高い光学性能を得るために、球面収差、非点収差、歪曲収差及び色収差等の変動を補正する必要最小限の設計自由度により構成している。

【００４４】又、条件式（３）の如く後群の負レンズＬＮ２１の焦点距離を定めて、フォーカシング時の収差変動を抑制するようにしている。

【００４５】条件式（３）の上限値を越えフォーカス移動群である後群の焦点距離Ｆｃ１２が大きくなると、合焦作用による繰出し量が増大する。このため前玉レンズ群Ｆ内のデッドスペースが増え、ズームレンズの大きさや重量を左右する前玉レンズ群全体が大型化してしまう。逆に、下限を越え後群の焦点距離Ｆｃ１２が小さく

なると、前玉レンズ群全体は小型化が図れるものの、後群Ｆ１２を構成する各レンズエレメントの曲率半径が急激に小さくなるため、ズーミングやフォーカシングによる収差変動を補正することが困難となってくる。

【００４６】以上の構成のもとで、本願発明の目的は達成されるが、このことに加え、各レンズエレメントに用いる材質にも留意して極めて高い光学性能を得るようにしている。例えばＣ線、Ｆ線のような２つの波長について１次の色消しをした場合は、２次スペクトルが残存する。この１次の色消しに対して例えばｇ線まで含んだ３つの波長について色補正されたレンズをアポクロマートと言うが、このアポクロマートを達成するためには、正レンズと負レンズより構成し、それらのアッベ数を大きく離したことによる色収差補正の１次の色消しに加えて、部分分散の値が揃っている材質を用いることが必要となる。

【００４７】ここで部分分散比とは主分散n_F-n_Cに対する任意の２つの波長λ_1，λ_2の部分分散

【００４８】

【外５】

$$n_{\lambda_1}-n_{\lambda_2}$$

の比のことである。

【００４９】Ｃ線、Ｆ線、ｇ線の３点について色消しがなされていれば色収差カーブは連続であるため、４００ｎｍ～７００ｎｍの可視域全般に対して残存色収差は非常に小さくなる。

【００５０】そこで、第１レンズ群におけるレンズの材質に関しては以下のように留意している。

（ｉ）前群については、前述の条件式のように近軸の色消しが必要なことから、１次の色消しをするために正レンズと負レンズのアッベ数の差を大きくしている。例えば正レンズはアッベ数が９０を越えるものを用いている。代表的なものにホタル石などの高異常分散な材質を用いている。これを逆に負レンズはアッベ数が小さいものを用いている。そのアッベ数の差は条件式（１）のとおりである。しかしながらアッベ数が非常に小さく、なおかつｇ線とｄ線の部分分散比Ｐｇｄがホタル石などの高異常分散の材質に近いものがほとんど存在していないのが現状である。

（ｉｉ）フォーカス移動群である後群は、物体側より１番目あるいは２番目に負レンズを配置している。これは、望遠端で軸上光線入射高ｈが最も高くなる位置であるため、望遠端の軸上色収差を減らすための色消しを実践するのに適した場所であることが理由にある。

【００５１】そこで、負レンズの部分分散比Ｐｐｄを条件式（４）のように制限している。これは、負レンズと小さな空気間隔であるいは接合という形で隣接する正レンズにアッベ数が６０以上で、部分分散比が比較的大きいものを用い、負レンズの部分分散比がそれとなるべく揃うような色消しの組合せにすることにより、望遠端の色消しにおいて最大の効果を挙げている。

【００５２】また条件式（４）の上限値を越えると正レンズと負レンズの部分分散比の差が著しく大きくなってくるため、望遠端での２次スペクトルの削減の効率が悪化する傾向となる。

（ｉｉｉ）後群の負レンズと正レンズの組合わせに続く正レンズは、同様にアッベ数が５４を越える材質を用い、なおかつ、なるべく高屈折率である材質を用いている。これは、望遠端の球面収差はもちろんのこと、広角側の像面湾曲やディストーションなどの軸外収差を補正するために曲率半径をなるべくゆるくするためや、前玉群として主点を出すためである。

【００５３】本実施例では以上のように、前玉レンズ群Ｆの光学配置及び制限条件を決定している。これらの光学配置及び制限条件を満足することにより、所謂フローティング効果を得ることができる。

【００５４】ここでフローティングとは、物体距離が変化して合焦する際に移動するレンズ群内のある任意の空気間隔を繰出しに応じて拡大、或いは縮小することにより、光線の通過する角度や高さを変化させて収差変動を抑制するものである。

【００５５】このように本実施例では、前玉レンズ群Ｆを固定の前群Ｆ１１とフォーカス移動のための後群Ｆ１２により構成し、パワー配置、レンズエレメントの材質、収差分担を適切に設定して、ズーム全域及びフォーカス全域での諸収差、特に球面収差と軸上色収差を良好に補正している。

【００５６】尚、ν_{11}，ν_{12}，ν_{21}に関しては複数存在する場合にはその平均値として定義する。

【００５７】ところでフォーカス移動群である後群Ｆ１２の中の負レンズＬＮ１２には、前述の条件（３）を満足させるには比較的強い屈折力を持たせることは望ましくない。こうした焦点距離のもとで、この負レンズのレンズ形状は条件式（５）の範囲内に抑えることが収差補正上好ましい。

【００５８】この条件式（３）と関連して条件式（５）において、下限値を下回る場合には、後群の中の負レンズは、発散の屈折力が強く、中心部に比べて周辺部が非常に厚いレンズ形状をしていることを示す。このような場合には以下に挙げるデメリットが顕著になってくる。

（ｉ）前述の図３３～図３６のフォーカス方式の比較で説明したことに対し、フォーカス移動群に発散の屈折力が強い負レンズが存在すると、近軸の光学配置では図３５に示すインナーフォーカス方式であっても、フォーカス固定群を出射する角度αが小さくなり、ｈｍ－ｈｆとｈｂ－ｈａの差が小さくなってしまう。故に、インナーフォーカス方式を採用しながらも収差変動を小さくすることが困難となる。

（ｉｉ）フォーカス移動群の中に発散の屈折力が強い負レンズが存在すると、全体として正の屈折力を有する第

１群の像側主点を押し出すことが困難となるため、近軸での光学配置の時点からデッドスペースが増えてしまい、小型化ができなくなる。

（ｉｉｉ）周辺部の厚みが厚くなりすぎると、広角側でフォーカス移動群の有効口径をいっぱいに通過する軸外光線ｈの高さが非常に高くなるため、前玉径が大きくなり、小型化が困難となる。

【００５９】逆に条件式（３）及び（５）において上限値を上回る場合には、後群の中の負レンズは発散の屈折力が非常に弱く、中心部と周辺部の厚みの差がほとんどない負レンズとなる。このような場合は、収差の打消しのための作用がほとんど無くなり、デッドスペースを増やすだけの存在になるばかりでなく、実際のレンズの加工においては製造の難易度は飛躍的に高くなる傾向となる。

【００６０】次に本発明のズームレンズは１４倍から４４倍程度のズーム比を有し、更にズーム全域にて大口径化を実現するために、まず前玉レンズ群（第１群）Ｆに条件式（６）を満足させている。これにより明るいレンズ系を用いている。下限値を越えると大口径化に対しては望ましい方向となるが、収差補正を行うことが困難となってくる。上限値を越えると明るいズームレンズを得ることが困難となる。

【００６１】又、この条件式の下で光学性能と第１レンズ群の小型化のバランスを考慮して、後群Ｆ１２の焦点距離Ｆｃ１２を制限する必要がある。放送用ズームレンズのように高い光学性能を要求されるズームレンズにおいては、無理な小型化を図って光学性能を低下させられないため条件式（７）の制限範囲内に後群の焦点距離を抑えるとよい。

【００６２】上限値を越えると、後群の光学的パワーが弱くなりフォーカスの際の移動量が大きくなるとともに、第１レンズ群の径が大型化してくる傾向にあり好ましくない。一方下限値を越えると後群の光学的パワーが強くなり、球面収差並びに変動する諸収差の補正が困難となる。

【００６３】ところで近軸領域で考慮すべき色消しについては前群Ｆ１１のみの色消しで充分であるが、しかしながら、実際にレンズを厚肉化する場合、特にインナーフォーカス化においては、第１レンズ群Ｆ全体の厚みは非常に大きくなるため、三次収差から厚肉化の誤差が大きくなってしまう。そこで三次の領域からの誤差を補正するための色消しが必要となり、条件式（８）～（１０）で規定している。ＥＦ，ＥＭは共に色消しの度合いを示すパラメータであり、ＥＴ＝ＥＭ＝０であれば第１群Ｆにおける色消しは充分なものとなり、望遠端での軸上色収差の量は減少する。ＥＦ及びＥＭを０に近づける手法として、

（ｉ）各レンズエレメントの焦点距離を大きくする。

（ｉｉ）各レンズエレメントの材質のアッベ数を大きくする。

（ｉｉｉ）各群のレンズエレメントの構成を正レンズと負レンズにより構成し、打消す。

ことが挙げられる。しかしながら、（ｉ）の項目はズームレンズ全系の小型に相反する。（ｉｉ）の項目は材質のアッベ数は実際には２０～９５程度の幅しかなく、限度がある。よって（ｉｉｉ）の項目が最も有効な手段となる。特にインナーフォーカス方式では前群Ｆ１１は従来より負レンズと正レンズの組合せによりＥＦの値を０に近づけることが比較的に容易であったが、フォーカス移動群である後群は従来より複数の正レンズのみで構成されており、ＥＭの値を０に近づけることが困難となっていた。フォーカス移動群を正レンズのみで構成していた理由としては、１つはできるだけ小型化を図る狙いがあったことと、もう１つは、特に望遠端で残存色収差が、実使用上問題の少ないレベルであったからである。しかしながら、ハイビジョンのような高精細な映像となると、ズームレンズを使用する際の空間周波数は従来方式の実に３倍にもなるため、特に望遠端の色収差を極限まで補正する必要がある。そこで、前群Ｆ１１と後群１２における色消しを条件式（８），（９）のように小さく補正しなければならない。

【００６４】条件式（１０）は第１レンズ群Ｆとしての前玉群全体の色消しの度合い、即ち、前群と後群の色収差の打ち消しを示すパラメータである。この条件式（１０）の下限値を下回ることは前玉群における色消しの補正不足となり、上限値を上回ることは逆に色消しの過剰となり、いずれの場合にもバリエータ以降の光学系において、前玉群の色消しの過不足をキャンセルする補正のため、色消しの過不足が生じ、ズーム中間域での色収差の変動が大きくなるなどの弊害が出てくる。これと同様のことが前玉群内部にもあてまる。条件式（８）において、ＥＦの値が下限値を下回ると、前玉群内の色収差を打ち消すためには、フォーカス移動群の色消しＥＭは上限値を越えて打ち消そうとする。このため、図３５でも説明したように無限遠とＭＯＤにおける軸上光線入射高ｈの変化に加えてフォーカス移動群が色消し不足となっているため軸上色収差のフォーカスによる変動が大きくなってしまう。

【００６５】逆に、条件式（８）においてＥＦの値が正となると、フォーカス移動群Ｆ１２の色消しは負となる必要性が出てくる。条件式（７）を満足しつつＥＭの値を負にするためには非常に発散の屈折力の強い負レンズがフォーカス移動群に存在する必要が出てくる。

【００６６】次に本発明の数値実施例を示す。数値実施例においてＲｉは物体側より順に第ｉ番目のレンズ面の曲率半径、Ｄｉは物体側より第ｉ番目のレンズ厚及び空気間隔、Ｎｉとνｉは各々物体側より順に第ｉ番目のレンズのガラスの屈折率とアッベ数である。数値実施例において、最終の２つ又は３つのレンズ面はフェースプレ

ートやフィルター等のガラスブロックである。

【００６７】又前述の各条件式と数値実施例における諸数値との関係を表－１に示す。

【００６８】非球面形状は光軸方向にＸ軸、光軸と垂直方向にＨ軸、光の進行方向を正としＲを近軸曲率半径、Ｋ，A_2，A_3，A_4，A_5 を各々非球面係数としたとき、

【００６９】

【外６】

$$X = \frac{(1/R)H^2}{1+\sqrt{1-(1+k)(H/R)^2}} + A_2H^4 + A_3H^6 + A_4H^8 + A_5H^{10}$$

なる式で表わしている。

【００７０】

【外７】

〔数値実施例1〕

f=9.00　　fno=1:1.7～2.0　　2ω= 62.9° ～5.4°

r 1= -899.355		d 1= 2.50	n 1= 1.76168	ν 1= 27.5	Pg′ d=1.31585
r 2= 110.946		d 2= 4.24			
r 3= 179.567		d 3= 10.43	n 2= 1.43985	ν 2= 95.0	Pg′ d=1.22944
r 4= -162.561		d 4= 6.98			
r 5= 102.046		d 5= 2.00	n 3= 1.61673	ν 3= 43.8	Pg′ d=1.26305
r 6= 60.702		d 6= 0.02			
r 7= 60.679		d 7= 16.09	n 4= 1.62032	ν 4= 63.4	Pg′ d=1.24000
r 8= -228.657		d 8= 0.15			
r 9= 54.929		d 9= 5.77	n 5= 1.73234	ν 5= 54.7	Pg′ d=1.23988
r10= 105.402		d10= 可変			
r11= 53.206		d11= 0.80	n 6= 1.88814	ν 6= 40.8	
r12= 21.213		d12= 4.57			
r13= -41.416		d13= 0.80	n 7= 1.82017	ν 7= 46.6	
r14= 24.709		d14= 3.23			
r15= 28.065		d15= 0.80	n 8= 1.83945	ν 8= 42.7	
r16= 20.728		d16= 5.00	n 9= 1.76260	ν 9= 25.1	
r17= -45.909		d17= 0.80	n10= 1.88814	ν 10= 40.8	
r18= 103.594		d18= 可変			
r19= -29.943		d19= 0.90	n11= 1.76077	ν 11= 47.8	
r20= 40.810		d20= 2.36	n12= 1.85501	ν 12= 23.9	
r21= 1201.272		d21= 可変			
r22=	(絞り)	d22= 1.10			
r23= 159.295		d23= 3.33	n13= 1.70558	ν 13= 41.2	
r24= -60.368		d24= 0.20			
r25= 119.213		d25= 2.27	n14= 1.50349	ν 14= 56.4	
r26= -1478.014		d26= 0.20			
r27= 74.499		d27= 6.29	n15= 1.50349	ν 15= 56.4	
r28= -26.004		d28= 1.30	n16= 1.80811	ν 16= 46.6	
r29= -114.378		d29= 28.00			
r30= 72.105		d30= 6.11	n17= 1.48915	ν 17= 70.2	
r31= -40.249		d31= 0.20			
r32= -92.459		d32= 1.40	n18= 1.83932	ν 18= 37.2	
r33= 46.430		d33= 6.75	n19= 1.50014	ν 19= 65.0	
r34= -49.362		d34= 0.20			
r35= 86.161		d35= 6.49	n20= 1.48915	ν 20= 70.2	
r36= -26.372		d36= 1.40	n21= 1.83945	ν 21= 42.7	
r37= -177.791		d37= 0.20			
r38= 38.470		d38= 4.22	n22= 1.60548	ν 22= 60.7	
r39= 1675.041		d39= 4.10			
r40= ∞		d40= 30.00	n23= 1.60718	ν 23= 38.0	
r41= ∞		d41= 16.20	n24= 1.51825	ν 24= 64.2	
r42= ∞					

焦点距離 / 可変間隔	9.00	18.00	36.00	72.00	117.00
d 10	0.88	20.42	33.62	42.45	46.47
d 18	47.01	24.56	9.78	3.30	4.71
d 21	5.40	8.31	9.88	7.54	2.10

【００７１】

【外８】

〔数値実施例２〕

f=8.50　　fno=1:1.7～2.1　　2ω= 65.8°～4.8°

r 1=	-255.551		d 1=	2.50	n 1= 1.74553	ν 1= 31.7	Pg′ d=1.29828
r 2=	116.017		d 2=	3.32			
r 3=	159.478		d 3=	10.66	n 2= 1.43985	ν 2= 95.0	Pg′ d=1.22944
r 4=	-169.489		d 4=	5.96			
r 5=	131.149		d 5=	2.20	n 3= 1.61669	ν 3= 44.2	Pg′ d=1.26190
r 6=	75.618		d 6=	0.02			
r 7=	75.377		d 7=	12.37	n 4= 1.43985	ν 4= 95.0	Pg′ d=1.22944
r 8=	-525.485		d 8=	0.15			
r 9=	93.787		d 9=	10.38	n 5= 1.60520	ν 5= 65.5	Pg′ d=1.23561
r10=	-299.830		d10=	0.15			
r11=	54.733		d11=	5.40	n 6= 1.73234	ν 6= 54.7	Pg′ d=1.23988
r12=	92.732		d12=	可変			
r13=	48.885		d13=	0.90	n 7= 1.88814	ν 7= 40.8	
r14=	17.522		d14=	4.68			
r15=	-53.332		d15=	0.80	n 8= 1.82017	ν 8= 46.6	
r16=	25.118		d16=	4.28			
r17=	28.654		d17=	4.15	n 9= 1.82600	ν 9= 23.7	
r18=	-53.487		d18=	0.59			
r19=	-34.766		d19=	0.80	n10= 1.77621	ν10= 49.6	
r20=	88.499		d20=	可変			
r21=	-27.616		d21=	0.90	n11= 1.77621	ν11= 49.6	
r22=	43.086		d22=	2.42	n12= 1.85501	ν12= 23.9	
r23=	-481.564		d23=	可変			
r24=		(絞り)	d24=	1.10			
r25=	231.826		d25=	3.56	n13= 1.51977	ν13= 52.4	
r26=	-46.618		d26=	0.20			
r27=	168.010		d27=	3.04	n14= 1.51977	ν14= 52.4	
r28=	-81.919		d28=	0.20			
r29=	69.136		d29=	6.07	n15= 1.51977	ν15= 52.4	
r30=	-30.903		d30=	1.30	n16= 1.82017	ν16= 46.6	
r31=	-320.915		d31=	32.00			
r32=	49.972		d32=	6.30	n17= 1.48915	ν17= 70.2	
r33=	-48.901		d33=	0.20			
r34=	-289.282		d34=	1.40	n18= 1.83932	ν18= 37.2	
r35=	28.438		d35=	6.00	n19= 1.50349	ν19= 56.4	
r36=	782.437		d36=	0.20			
r37=	68.152		d37=	6.91	n20= 1.48915	ν20= 70.2	
r38=	-25.893		d38=	1.40	n21= 1.83932	ν21= 37.2	
r39=	-65.266		d39=	0.20			
r40=	40.256		d40=	4.43	n22= 1.51314	ν22= 60.5	
r41=	-609.030		d41=	4.00			
r42=	∞		d42=	30.00	n23= 1.60718	ν23= 38.0	
r43=	∞		d43=	16.20	n24= 1.51825	ν24= 64.2	
r44=	∞						

焦点距離 / 可変間隔	8.50	17.00	34.00	68.00	127.50
d 12	0.80	19.24	31.64	39.85	44.35
d 20	44.49	23.25	9.39	3.47	6.23
d 23	6.20	8.99	10.45	8.17	0.80

【００７２】

【外９】

〔数値実施例3〕

f=8.00　　fno=1:1.7～2.7　　2ω= 69.0°～3.9°

r 1=	-200.224	d 1=	2.70	n 1=	1.85649	ν 1=	32.3	Pg′ d=	1.29992
r 2=	186.083	d 2=	6.51						
r 3=	455.997	d 3=	12.01	n 2=	1.43985	ν 2=	95.0	Pg′ d=	1.22944
r 4=	-127.284	d 4=	7.88						
r 5=	142.838	d 5=	2.50	n 3=	1.79013	ν 3=	44.2	Pg′ d=	1.26490
r 6=	99.498	d 6=	0.02						
r 7=	98.215	d 7=	15.15	n 4=	1.43985	ν 4=	95.0	Pg′ d=	1.22944
r 8=	-234.945	d 8=	0.20						
r 9=	114.271	d 9=	10.09	n 5=	1.60520	ν 5=	65.5	Pg′ d=	1.23561
r10=	-511.370	d10=	0.15						
r11=	59.804	d11=	6.26	n 6=	1.60520	ν 6=	65.5	Pg′ d=	1.23561
r12=	114.982	d12=	可変						
r13=	47.010	d13=	0.90	n 7=	1.88814	ν 7=	40.8		
r14=	16.663	d14=	6.70						
r15=	-56.863	d15=	0.80	n 8=	1.82017	ν 8=	46.6		
r16=	33.831	d16=	4.47						
r17=	29.158	d17=	5.32	n 9=	1.82600	ν 9=	23.7		
r18=	-52.029	d18=	0.90						
r19=	-31.823	d19=	0.80	n10=	1.75844	ν10=	52.3		
r20=	72.877	d20=	可変						
r21=	-29.012	d21=	0.75	n11=	1.77621	ν11=	49.6		
r22=	70.928	d22=	1.24	n12=	1.93301	ν12=	21.3		
r23=	-370.095	d23=	可変						
r24=	(絞り)	d24=	1.30						
r25=	263.190	d25=	4.11	n13=	1.62287	ν13=	60.3		
r26=	-54.541	d26=	0.18						
r27=	156.992	d27=	3.30	n14=	1.50014	ν14=	65.0		
r28=	-126.947	d28=	0.15						
r29=	47.125	d29=	7.68	n15=	1.50349	ν15=	56.4		
r30=	-40.483	d30=	1.50	n16=	1.83945	ν16=	42.7		
r31=	-252.408	d31=	28.00						
r32=	78.868	d32=	5.51	n17=	1.48915	ν17=	70.2		
r33=	-41.808	d33=	0.30						
r34=	-67.885	d34=	1.40	n18=	1.88814	ν18=	40.8		
r35=	23.625	d35=	7.81	n19=	1.51825	ν19=	64.2		
r36=	-67.344	d36=	0.20						
r37=	51.956	d37=	5.93	n20=	1.51314	ν20=	60.5		
r38=	-33.404	d38=	1.30	n21=	1.83945	ν21=	42.7		
r39=	-888.472	d39=	0.15						
r40=	35.701	d40=	5.19	n22=	1.51825	ν22=	64.2		
r41=	-78.383	d41=	4.50						
r42=	∞	d42=	30.00	n23=	1.60718	ν23=	38.0		
r43=	∞	d43=	16.20	n24=	1.51825	ν24=	64.2		
r44=	∞								

焦点距離 / 可変間隔	8.00	16.00	48.00	96.00	160.00
d 12	0.52	22.64	43.59	51.03	54.34
d 20	58.26	32.92	9.50	5.75	9.23
d 23	6.00	9.22	11.70	8.01	1.21

【００７３】

【外１０】

〔数値実施例４－１〕

f=10.00000　　fno=1:1.8～4.0　　2ω= 57.6°～1.4°

r 1=	258.310		d 1= 5.50	n 1= 1.83932	ν 1= 37.2	Pg′ d=1.28253
r 2=	147.470		d 2= 0.04			
r 3=	145.655		d 3= 19.52	n 2= 1.43496	ν 2= 95.1	Pg′ d=1.23247
r 4=	1788.734		d 4= 11.37			
r 5=	502.121		d 5= 11.81	n 3= 1.43496	ν 3= 95.1	Pg′ d=1.23247
r 6=	-540.542		d 6= 0.15			
r 7=	-525.580		d 7= 5.00	n 4= 1.77621	ν 4= 49.6	Pg′ d=1.24984
r 8=	-4050.532		d 8= 0.30			
r 9=	188.279		d 9= 18.58	n 5= 1.43496	ν 5= 95.1	Pg′ d=1.23247
r10=	-779.770		d10= 0.30			
r11=	144.762		d11= 11.15	n 6= 1.49845	ν 6= 81.6	Pg′ d=1.23153
r12=	333.208		d12= 可変			
r13=	337.087		d13= 2.00	n 7= 1.82017	ν 7= 46.6	
r14=	54.313		d14= 4.71			
r15=	-170.414		d15= 1.80	n 8= 1.77621	ν 8= 49.6	
r16=	50.612		d16= 6.91			
r17=	-66.371		d17= 1.80	n 9= 1.82017	ν 9= 46.6	
r18=	45.577		d18= 7.83	n10= 1.93306	ν10= 21.3	
r19=	-346.002		d19= 可変			
r20=	9753.850		d20= 6.52	n11= 1.49845	ν11= 81.6	
r21=	-113.140		d21= 0.30			
r22=	190.740		d22= 2.50	n12= 1.65223	ν12= 33.8	
r23=	54.467		d23= 13.62	n13= 1.59143	ν13= 61.2	
r24=	-152.092		d24= 0.20			
r25=	118.516		d25= 13.11	n14= 1.62032	ν14= 63.4	
r26=	-76.404		d26= 2.50	n15= 1.85501	ν15= 23.9	
r27=	-155.554		d27= 0.20			
r28=	89.671	(非球面)	d28= 3.78	n16= 1.48915	ν16= 70.2	
r29=	168.002		d29= 可変			
r30=		(絞り)	d30= 3.29			
r31=	-52.660		d31= 1.80	n17= 1.79013	ν17= 44.2	
r32=	33.435		d32= 4.19	n18= 1.81265	ν18= 25.4	
r33=	142.254		d33= 6.15			
r34=	-44.772		d34= 1.60	n19= 1.73234	ν19= 54.7	
r35=	30.867		d35= 10.72	n20= 1.59911	ν20= 39.2	
r36=	-30.393		d36= 24.00			
r37=	400.206		d37= 5.86	n21= 1.48915	ν21= 70.2	
r38=	-31.694		d38= 0.20			
r39=	-43.632		d39= 2.20	n22= 1.79013	ν22= 44.2	
r40=	41.339		d40= 6.15	n23= 1.50349	ν23= 56.4	
r41=	-49.159		d41= 1.10			
r42=	1051.682		d42= 6.15	n24= 1.55099	ν24= 45.8	
r43=	-29.627		d43= 2.20	n25= 1.81265	ν25= 25.4	
r44=	-83.226		d44= 0.20			
r45=	73.620		d45= 4.26	n26= 1.51977	ν26= 52.4	
r46=	-74.825		d46= 5.00			
r47=	∞		d47= 50.00	n27= 1.51825	ν27= 64.2	
r48=	∞					

非球面形状　　参照球面　　R=89.671

非球面係数　　A=B=C=E=0　　$D=5.99704\times10^{-14}$

【００７４】

【外１１】

〔数値実施例４－２〕

焦点距離 / 可変間隔	10.00	19.49	69.79	257.37	441.10
d 12	1.72	43.72	91.72	115.22	120.72
d 19	176.93	129.87	67.75	20.44	0.87
d 29	3.30	8.36	22.48	46.29	60.36

【００７５】

【表１】

表-1

	数値実施例			
	1	2	3	4
$\nu_{11N}-\nu_{12P}$	-67.46	-63.31	-62.68	-57.93
$\nu_{11N}-\nu_{21N}$	-16.33	-12.58	-11.90	-12.43
f_{21}/F_{C12}	-3.728	-4.967	-6.366	-4.009
$(n_g-n_d)/(n_F-n_C)$	1.263	1.262	1.265	1.2498
$\left\|\frac{r_b+r_a}{r_b-r_a}\right\|$	3.936	3.723	5.591	1.298
FN1	1.197	1.054	1.198	1.696
$f_{C12}/F1$	0.948	0.925	0.942	1.038
EF	-2.269×10^{-4}	-2.402×10^{-4}	-2.297×10^{-4}	-3.527×10^{-5}
EM	2.300×10^{-4}	2.273×10^{-4}	1.885×10^{-4}	4.582×10^{-5}
EF/EM	-0.987	-1.056	-1.218	-0.770

【００７６】次に本発明の各数値実施例の特徴について説明する。

【００７７】図１に示す数値実施例１は１３倍を越えるズーム比を有し、Ｒ１～Ｒ１０は第１レンズ群Ｆ（フォーカス群Ｆ）である。このうちＲ１～Ｒ４はズーミング、フォーカスに際して固定であり全体で負のパワー（屈折力）を有するフォーカス固定群Ｆ１１である。Ｒ５～Ｒ１０は前群Ｆ１２で正のパワーを有する。Ｒ１～Ｒ１０によりバリエータＶに対する物点を結ぶ作用を有する第１レンズ群Ｆ作用をなし、第１レンズ群Ｆ全体で正のパワーを有する。

【００７８】Ｒ１１～Ｒ１８は主に変倍に寄与し、ワイドからテレへの変倍に際し、像面側へ単調に移動し、途中で結像倍率－１倍（等倍）を通過するバリエータＶである。Ｒ１９～Ｒ２１はコンペンセータＣで、主に変倍に伴う像点補正の作用を有し、かつ変倍作用をも有する。コンペンセータＣは正のパワーを有し、ワイドからテレへの変倍に際し、広角端基準位置から物体側へ単調に移動する。ＳＰ（Ｒ２２）は絞りである。

【００７９】Ｒ２３～Ｒ３９は結像作用を有するリレー群Ｒであり、Ｒ４０～Ｒ４２は色分解プリズムと等価なガラスフロックである。

【００８０】大口径化の指標として前玉レンズ群のＦナンバーをＦＮ１＝ｆ１（ｆＴ／ＦＮＴ）と定義したとき、本実施例ではＦＮ１＝１．１９７である。

【００８１】これらの大口径、パワー分担に対し第１レンズ群では球面収差や軸上色収差の補正の為にフォーカス固定群に１つの負レンズと１つの正レンズを配置し、フォーカス移動群に２つの正レンズを用いて分担させて補正している。

【００８２】一般に前玉レンズ群Ｆはそのレンズ構成ができるだけシンプルでブロックの厚みが小さい方がズーム全系の小型や駆動系の省電力化等に好ましい。この為、前玉レンズ群Ｆはできるだけレンズ枚数を少なくすることが望まれる。

【００８３】これに対し、前述のように前玉レンズ群のＦナンバーＦＮ１は非常に明るいものとなり、加えて前玉のパワー分担も強いものとなるため、ズーミング、フォーカスによる球面収差、軸上色収差等を補正することが難しくなってくる。

【００８４】そこで本実施例では前群レンズの材質の屈折率が非常に高い負レンズを用い、同時に前群中に材質のアッベ数が非常に大きい正レンズを用いることにより、球面収差と軸上色収差の発生を抑えている。この時前群の負レンズそして正レンズの材質のアッベ数の差は

$\nu_{11}-\nu_{12}=-67.46$ である。

【００８５】このときの後群F_{C12}中の負レンズの屈折力は

$f_{21}/F_{C12}=-3.728$

となっており、同負レンズの材質の部分分散比とシェイプファクタはそれぞれ

$(ng-nd)/(nF-nc)=1.263$

【００８６】

【外１２】

$$\left|\frac{r_b+r_a}{r_b-r_a}\right| = 3.936$$

となっている。

【００８７】また前群と後群の色消し分担の目安である

負レンズ同士の材質のアッベ数の差$\nu_{11}-\nu_{21}$は
$\nu_{11}-\nu_{21}$＝－１６．３３
となっている。
【００８８】図２に示す数値実施例２は１５倍を越えるズーム比を有し、Ｒ１～Ｒ１２は第１レンズ群Ｆ（フォーカス群Ｆ）である。このうちＲ１～Ｒ４はズーミング、フォーカスに際して固定であり、全体で正のパワー（屈折力）を有するフォーカス固定群Ｆ１１であり、Ｒ５～Ｒ１２はフォーカス移動群である後群Ｆ１２で正のパワーを有する。Ｒ１～Ｒ１２によりバリエータＶに対する物点を結ぶ作用を有する前玉レンズ群Ｆの作用をなし、前玉レンズ群Ｆ全体で正のパワーを有する。
【００８９】Ｒ１３～Ｒ２０は主に変倍に寄与し、ワイドからテレへの変倍に際し像面側へ単調に移動し、途中で結像倍率－１倍（等倍）を通過するバリエータＶである。Ｒ２１～Ｒ２３はコンペンセータで、主に変倍に伴う像点補正の作用を有するコンペンセータＣは負のパワーを有し、ワイドからテレへの変倍に際し広角端基準位置から物体側へ移動し、ある焦点距離より像側へ移動し、望遠端では広角端基準位置よりも像側に存在する。ＳＰ（Ｒ２４）は絞りである。
【００９０】Ｒ２５～Ｒ４１は結像作用を有するリレー群Ｒであり、Ｒ４２～Ｒ４４は色分解プリズムと等価なガラスブロックである。
【００９１】数値実施例１に比べてズーム比は１５倍と高倍率ながら、広角端の画角２ω＝６５．８°を達成している。
【００９２】この広角化を達成するためには歪曲収差や倍率色収差等、画角に大きく影響される諸収差を良好に補正する必要がある。又、前玉ＦナンバーがＦＮ１＝１．０５４と非常に明るいものとなっている。
【００９３】そこで本実施例では、フォーカス移動群である後群を１つの負レンズと３つの正レンズにより構成している。しかも前群と後群のそれぞれの負レンズのアッベ数の差$\nu_{11}-\nu_{21}$を－１２．５８とすることにより、広角にもかかわらず良好な色収差補正を行っている。又後群においても、３つの正レンズのうち像面側の正レンズの材質の屈折率を比較的高いものとすることにより、球面収差や歪曲収差を良好に補正しながらも色収差補正に寄与するような光学配置としている。
【００９４】図３の数値実施例３は数値実施例２に比べて略同じレンズ構成でありながら、パワー配置の適切な選択により、更に広角化、高変倍化を達成しており、ズーム比は２０倍である。
【００９５】しかも同時にコンパクト化を図るため、各レンズ群のパワー分担を強くバリエータＶやコンペンセータＣの変倍の際の移動量を減らしている。
【００９６】このため第１レンズ群のＦナンバーは１．１９８と厳しいものになっている。加えてさらなる広角化のために第１レンズ群のレトロ比を上げざるを得ない。また望遠端の焦点距離も１６０mmに達することから、望遠端の特に色収差の補正が困難になってくる。
【００９７】そこで本実施例では、前群と後群は比較的屈折率が高く、アッベ数が非常に小さい負レンズとアッベ数が非常に大きな正レンズとにより構成し、$\nu_{11}-\nu_{12}$が－６２．６８，$\nu_{11}-\nu_{21}$が－１１．９０としている。そして前群の色消しを後群にさらに持たせることにより、ズーム、フォーカス全域にて諸収差の変動を良好に抑えている。
【００９８】又、実施例２，３のように後群を３つの正レンズにより構成していることにより、特にフォーカスによる諸収差の変動を良好に抑えている。これはフォーカス移動群の設計の自由度を増やしたことにより、
（ｉ）球面収差のみならず、他の非点収差等の変動補正にも余裕ができるので光学性能のうち特に解像力を向上させている
（ｉｉ）レンズエレメントの材質の選択の幅が広くなるので、特にアッベ数の非常に大きな正レンズを採用し、フォーカス移動群の色消しを向上させて、色収差の変動を減らし、映像の色にじみを削減している
等の効果を導出している。
【００９９】図４に示す数値実施例４は広角端の画角は２ω＝５７．６°程度であるが、ズーム比が４４倍もあり望遠端の画角は２ω＝１．４°という非常に高倍率なズームレンズである。
【０１００】本実施例は望遠端の焦点距離が非常に長いので球面収差の補正、及び軸上色収差の補正が困難となってくる。まだズーム比も４４倍もあるため、諸収差のズーム変動の補正も同時に困難なものとなっている。
【０１０１】そこで本実施例では、数値実施例３のような広角ズームではないにもかかわらず、先ずフォーカス移動群を比較的屈折率の高い負レンズと３つの正レンズにて構成し、数値実施例３と同様の効果を導出している。次にコンペンセータＣのうち、Ｒ２８面に非球面を施しており、特に望遠側の球面収差を補正している。そして、フォーカス固定群はもとより、フォーカス移動群においてもアッベ数が非常に大きい材質の正レンズエレメントを配置することにより色消しを向上させている。これらの手法により超長焦点の望遠端においても高い光学性能を得られるように収差補正を行なっている。
【０１０２】さらに後群内の負レンズは物体側に凹の負メニスカスレンズとなっており、主に像面湾曲やディストーションなど軸外光線収差補正に効かせている。
【０１０３】このとき、$\nu_{11}-\nu_{12}$＝－５７．９３，$\nu_{11}-\nu_{21}$＝－１２．４３となっており、特に望遠端の軸上色収差の２次スペクトルを飛躍的に減少させている。第４実施例での望遠端の軸上色収差は他の第１～第３実施例の望遠端の３倍もの焦点距離であるにもかかわらず２次スペクトル量はほぼ同等に補正されている。
【０１０４】

【発明の効果】本発明によれば以上のように、所謂４群ズームレンズにおいて、前玉群の屈折力やＦナンバー値等を適切に設定すると共に、前玉レンズ群をフォーカス固定群とフォーカス移動群に分割し、レンズエメレントの配置、屈折力分担、色消し分担の所定の条件を満足するような分割方式をとることにより、変倍及びフォーカシングに伴う球面収差、色収差の変動を少なくし、更に変倍に伴う非点収差、像面弯曲等の軸外収差の変動をバランス良く補正し、全変倍範囲、全フォーカス範囲にわたり高い光学性能を有した広角端のＦナンバー１．７程度、変倍比１３～４４程度の大口径比で高変倍比のズームレンズを達成することができる。

【０１０５】また、リレーの一部を変倍に応じて移動するズームレンズに本発明を適用しても同様の効果が得られる。

【図面の簡単な説明】

【図１】本発明の数値実施例１の広角端のレンズ断面図。

【図２】本発明の数値実施例２の広角端のレンズ断面図。

【図３】本発明の数値実施例３の広角端のレンズ断面図。

【図４】本発明の数値実施例４の広角端のレンズ断面図。

【図５】本発明の数値実施例１の焦点距離ｆ＝９．０，物体距離３．０ｍの収差図。

【図６】本発明の数値実施例１の焦点距離ｆ＝１８．０，物体距離３．０ｍの収差図。

【図７】本発明の数値実施例１の焦点距離ｆ＝３６．０，物体距離３．０ｍの収差図。

【図８】本発明の数値実施例１の焦点距離ｆ＝７２．０，物体距離３．０ｍの収差図。

【図９】本発明の数値実施例１の焦点距離ｆ＝１１７．０，物体距離３．０ｍの収差図。

【図１０】本発明の数値実施例１の焦点距離ｆ＝１１７．０，物体距離∞の収差図。

【図１１】本発明の数値実施例１の焦点距離ｆ＝１１７．０，物体距離０．９ｍの収差図。

【図１２】本発明の数値実施例２の焦点距離ｆ＝８．５，物体距離３．０ｍの収差図。

【図１３】本発明の数値実施例２の焦点距離ｆ＝１７．０，物体距離３．０ｍの収差図。

【図１４】本発明の数値実施例２の焦点距離ｆ＝３４．０，物体距離３．０ｍの収差図。

【図１５】本発明の数値実施例２の焦点距離ｆ＝６８．０，物体距離３．０ｍの収差図。

【図１６】本発明の数値実施例２の焦点距離ｆ＝１２７．５，物体距離３．０ｍの収差図。

【図１７】本発明の数値実施例２の焦点距離ｆ＝１２７．５，物体距離∞の収差図。

【図１８】本発明の数値実施例２の焦点距離ｆ＝１２７．５，物体距離０．９ｍの収差図。

【図１９】本発明の数値実施例３の焦点距離ｆ＝８．０，物体距離３．０ｍの収差図。

【図２０】本発明の数値実施例３の焦点距離ｆ＝１６．０，物体距離３．０ｍの収差図。

【図２１】本発明の数値実施例３の焦点距離ｆ＝４８．０，物体距離３．０ｍの収差図。

【図２２】本発明の数値実施例３の焦点距離ｆ＝９６．０，物体距離３．０ｍの収差図。

【図２３】本発明の数値実施例３の焦点距離ｆ＝１６０．０，物体距離３．０ｍの収差図。

【図２４】本発明の数値実施例３の焦点距離ｆ＝１６０．０，物体距離∞の収差図。

【図２５】本発明の数値実施例３の焦点距離ｆ＝１６０．０，物体距離０．９ｍの収差図。

【図２６】本発明の数値実施例４の焦点距離ｆ＝１０．０，物体距離１０．０ｍの収差図。

【図２７】本発明の数値実施例４の焦点距離ｆ＝１９．４９，物体距離１０．０ｍの収差図。

【図２８】本発明の数値実施例４の焦点距離ｆ＝６９．７９，物体距離１０．０ｍの収差図。

【図２９】本発明の数値実施例４の焦点距離ｆ＝２５７．３７，物体距離１０．０ｍの収差図。

【図３０】本発明の数値実施例４の焦点距離ｆ＝４４１．１０，物体距離１０．０ｍの収差図。

【図３１】本発明の数値実施例４の焦点距離ｆ＝４４１．１０，物体距離∞の収差図。

【図３２】本発明の数値実施例４の焦点距離ｆ＝４４１．１０，物体距離３．４ｍの収差図。

【図３３】従来の４群ズームレンズの第１群の近軸屈折力配置の説明図。

【図３４】従来の４群ズームレンズの第１群のレンズ断面図。

【図３５】従来の４群ズームレンズの第１群の近軸屈折力配置の説明図。

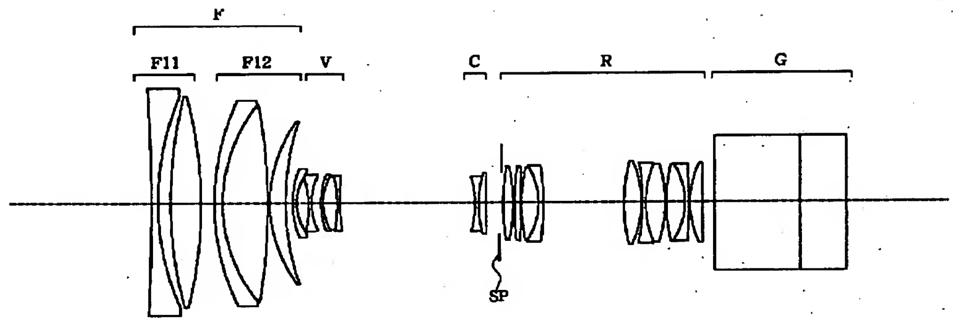
【図３６】従来の４群ズームレンズの第１群のレンズ断面図。

【符号の説明】

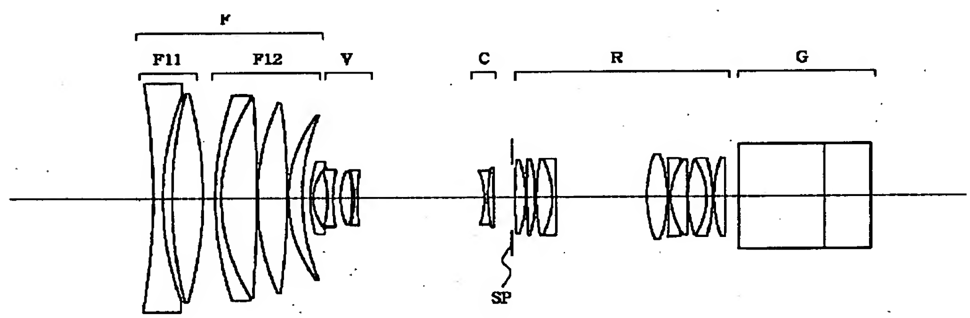
Ｆ　第１群（フォーカス群）
Ｆ１１　フォーカス固定群
Ｆ１２　フォーカス移動群
Ｖ　第２群（バリエータ）
Ｃ　第３群（コンペンセータ）
Ｒ　第４群（リレー群）
Ｇ　ガラスブロック
ＳＰ　絞り
ｅ　ｅ線
ｇ　ｇ線
ΔＳ　サジタル像面

ΔＭ　メリディオナル像面

【図１】



【図２】



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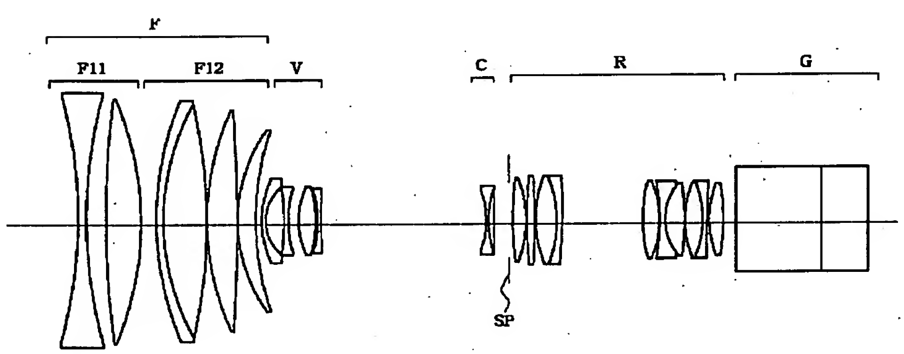

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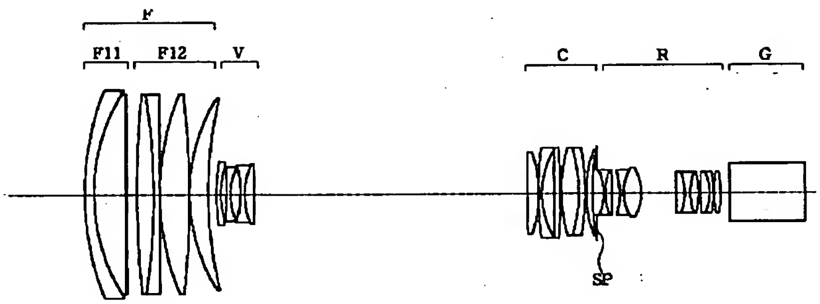

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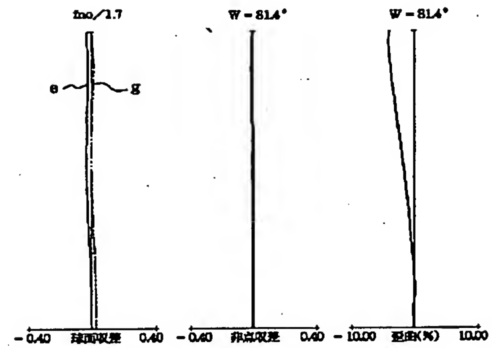

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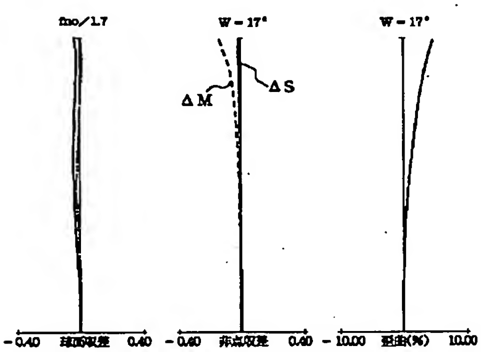

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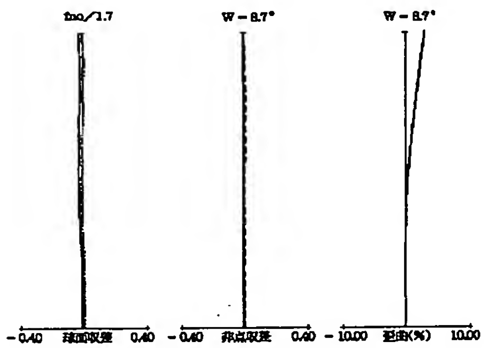

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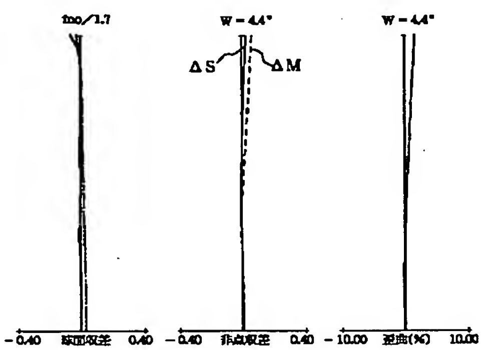

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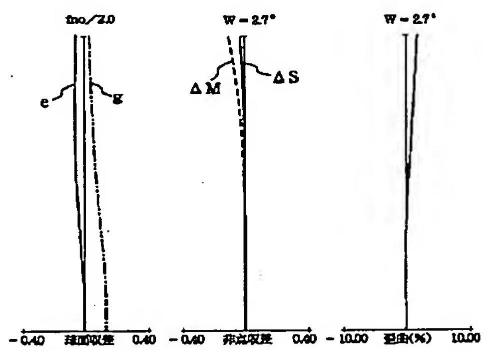

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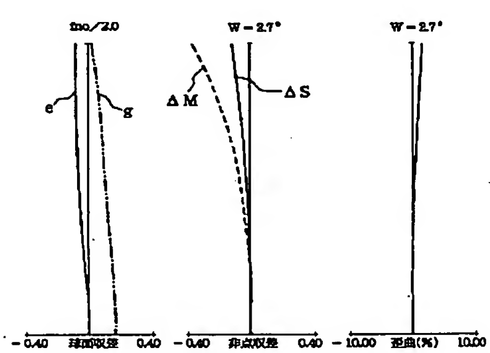

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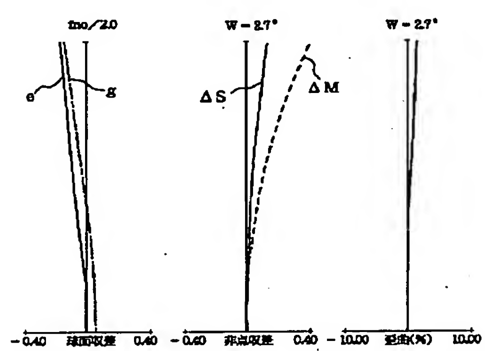
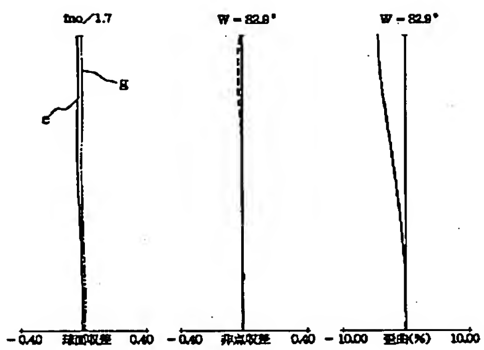
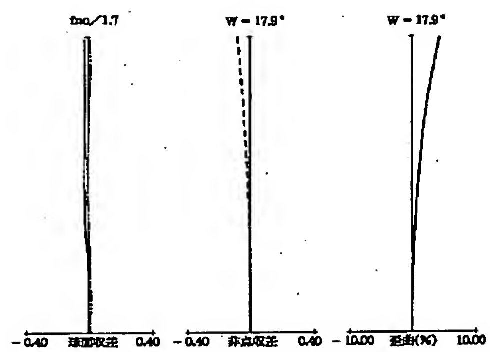


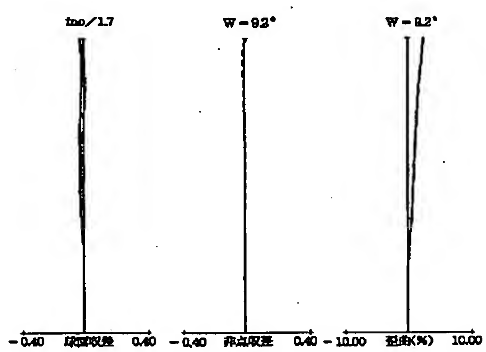
【図１２】



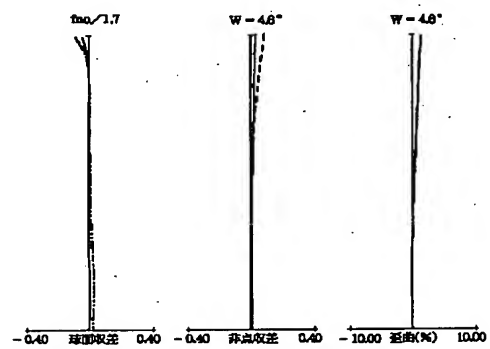
【図１３】



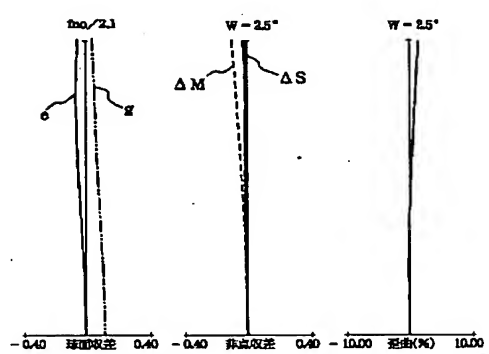
【図１４】



【図１５】



【図１６】



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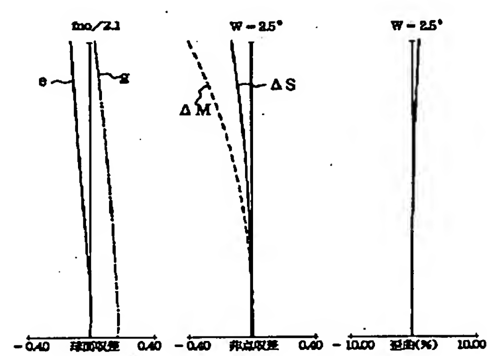
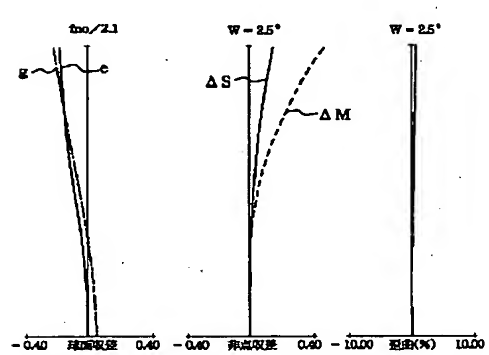
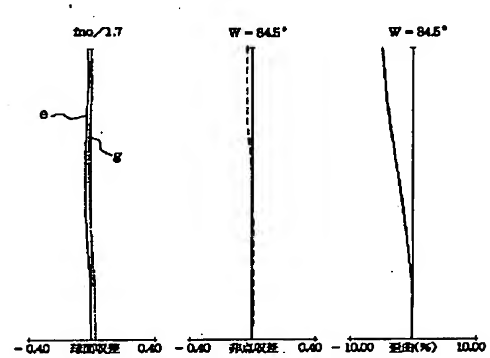


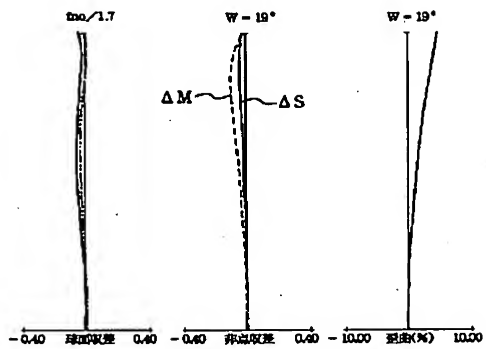
【図１８】



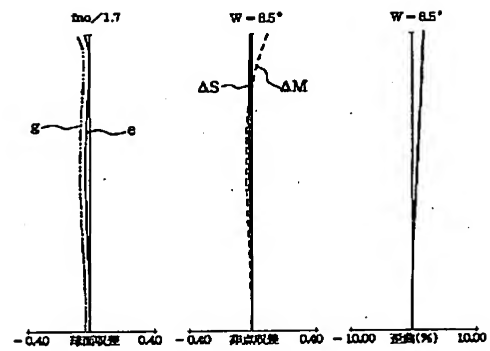
【図１９】



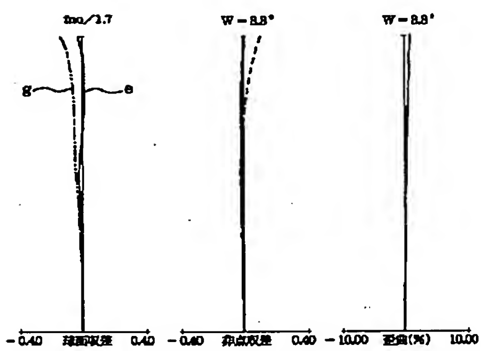
【図20】



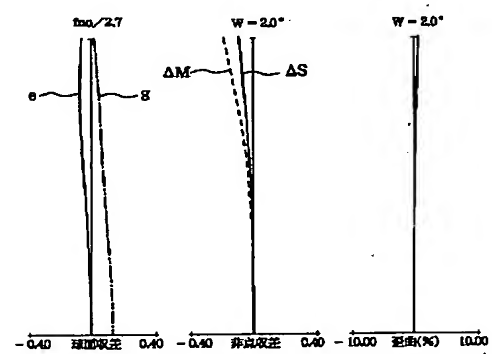
【図21】



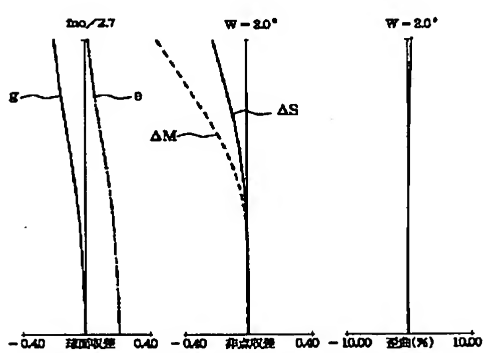
【図22】



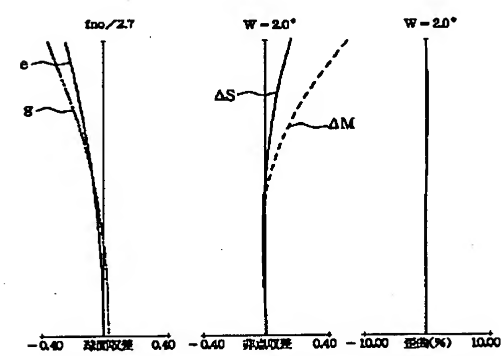
【図23】



【図24】



【図25】



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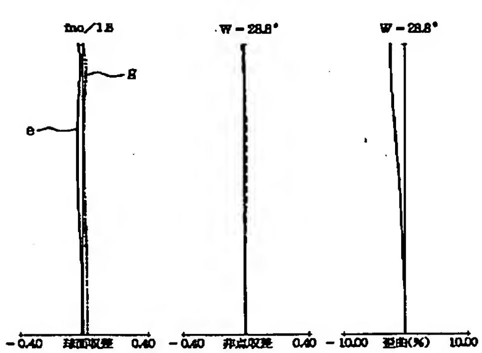
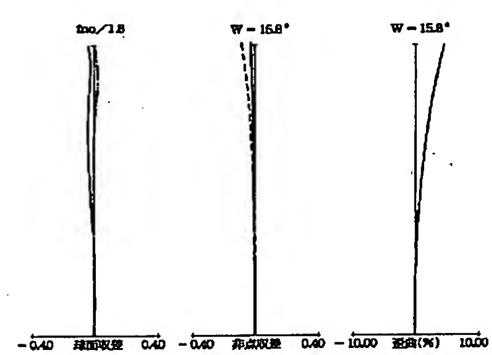


【図27】



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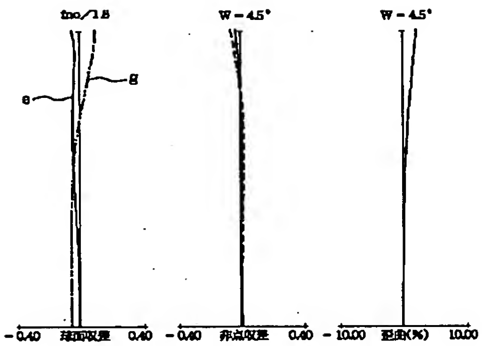

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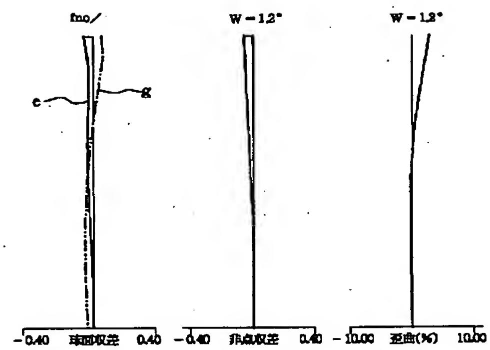
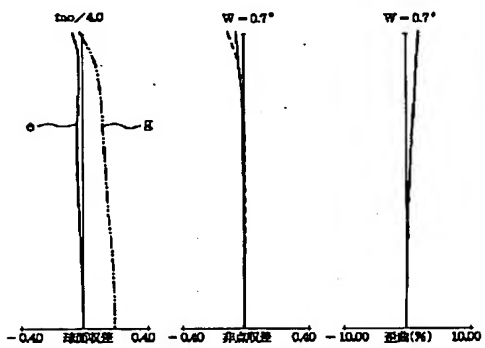


【図30】



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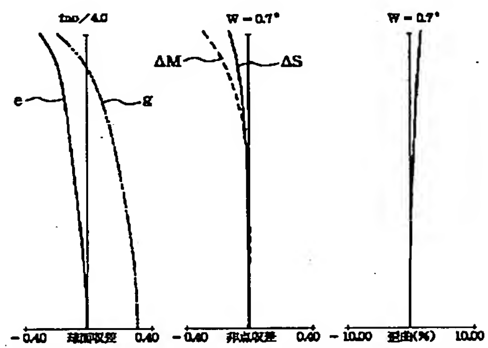

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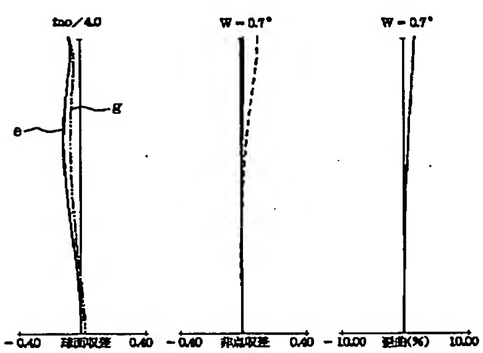

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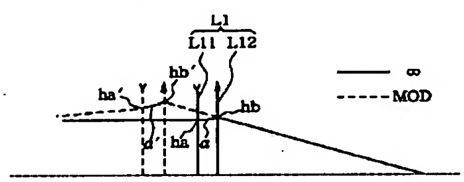

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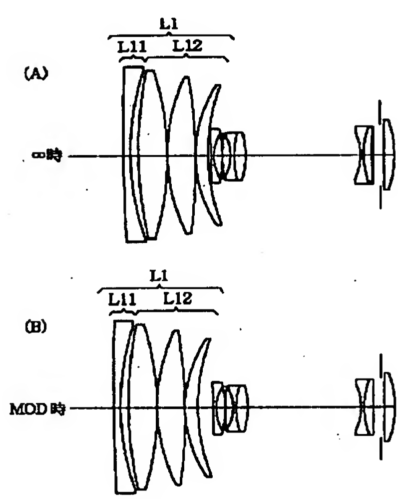

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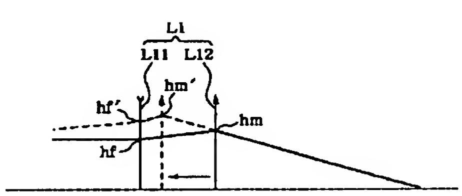

【図36】